Use of Radio Spectrum for CMA current and future MetSat systems

Current and future CMA MetSat systems

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National Satellite Meteorological Centre, CMA
Outline

- Overview of FENGYUN satellite systems
- FENGYUN Metsats Application
- Data and Products Service
- Use of Radio Spectrum
1. Overview of FENGYUN satellite systems

**Polar and low light orbit System**

- **First Generation**
  - FY-1 A, B, C, D

- **Second Generation**
  - FY-3 A, B, C, D, E, F, G

- Expected until 2025

**Geostationary System**

- **First Generation**
  - FY-2 A, B, C, D, E, F, G, H

- **Second Generation**
  - FY-4 A, B, C, D, E

- Expected until 2030
### Use of Radio Spectrum for CMA current and future Metsat systems

#### Polar-orbiting Series Launched Satellites

<table>
<thead>
<tr>
<th>Date</th>
<th>Satellite</th>
<th>Status</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988.09.07</td>
<td>FY-1A</td>
<td>Experimental</td>
<td>39 Days</td>
</tr>
<tr>
<td>1990.09.03</td>
<td>FY-1B</td>
<td>Experimental</td>
<td>158 Days</td>
</tr>
<tr>
<td>1999.05.10</td>
<td>FY-1C</td>
<td>Operational</td>
<td>6.5 Years</td>
</tr>
<tr>
<td>2002.05.15</td>
<td>FY-1D</td>
<td>Operational</td>
<td>&gt;10 Years</td>
</tr>
<tr>
<td>2008.05.17</td>
<td>FY-3A</td>
<td>Experimental</td>
<td>Operation</td>
</tr>
<tr>
<td>2010.11.05</td>
<td>FY-3B</td>
<td>Experimental</td>
<td>Operation</td>
</tr>
<tr>
<td>2013. 9.23</td>
<td>FY-3C</td>
<td>AM Orbit</td>
<td>Operation</td>
</tr>
</tbody>
</table>

#### Geostationary Series Launched Satellites

<table>
<thead>
<tr>
<th>Date</th>
<th>Satellite</th>
<th>Status</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997.06.10</td>
<td>FY-2A</td>
<td>Experimental</td>
<td>De-orbited</td>
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<tr>
<td>2000.06.25</td>
<td>FY-2B</td>
<td>Experimental</td>
<td>De-orbited</td>
</tr>
<tr>
<td>2004.10.19</td>
<td>FY-2C</td>
<td>Operational</td>
<td>De-orbited</td>
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<tr>
<td>2006.12.08</td>
<td>FY-2D</td>
<td>123.5E</td>
<td>backup</td>
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<tr>
<td>2008.12.23</td>
<td>FY-2E</td>
<td>86.5E</td>
<td>Operation</td>
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<tr>
<td>2012.01.13</td>
<td>FY-2F</td>
<td>112.5E</td>
<td>Operation</td>
</tr>
<tr>
<td>2014.12.31</td>
<td>FY-2G</td>
<td>105E</td>
<td>Operation</td>
</tr>
<tr>
<td>2016.12.11</td>
<td>FY-4A</td>
<td>Experimental, 105E</td>
<td>Operation</td>
</tr>
<tr>
<td>2018.12.11</td>
<td>FY-4B</td>
<td>105E</td>
<td>Operation</td>
</tr>
</tbody>
</table>
Use of Radio Spectrum for CMA current and future Metsat systems

On Orbit FENGYUN Satellites

- 6 satellites in operation
- 1 satellite in orbit test
- 1 satellite on backup
1.1 FENGYUN GEO Constellation

- **In operation**
  - FY-2G: Full Disk (105E)
  - FY-2E: Full Disk (86.5E)
  - FY-2F: Regional (112E)

- **In commission test**
  - FY-4A: (105E)

- **In backup**
  - FY-2D (123.5E)
Sencond Geostationary Generation: FY-4

Main Instruments:

1) AGRI: Advanced Geosynchronous Radiation Imager
2) GIIRS: Geo. Interferometric Infrared Sounder
3) LMI: Lightning Mapping Imager
4) SEP: Space Environment Package

Spacecraft:

1. Launch Weight: approx 5300kg
2. Stabilization: Three-axis
3. Attitude accuracy: 3"
4. Bus: 1553B+Spacewire
5. Output power: >= 3200W
Use of Radio Spectrum for CMA current and future Metsat systems

### Spectral Coverage

<table>
<thead>
<tr>
<th>Spectral Coverage</th>
<th>Spectral Band (µm)</th>
<th>Spatial Resolution (Km)</th>
<th>Sensitivity</th>
<th>Main Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIS/NIR</td>
<td>0.45~0.49</td>
<td>1</td>
<td>S/N≥90 (ρ=100%)</td>
<td>Aerosol</td>
</tr>
<tr>
<td></td>
<td>0.55~0.75</td>
<td>0.5~1</td>
<td>S/N≥200 (ρ=100%)</td>
<td>Fog, Clouds</td>
</tr>
<tr>
<td></td>
<td>0.75~0.90</td>
<td>1</td>
<td>S/N≥5(ρ=1%)@0.5Km</td>
<td>Vegetation</td>
</tr>
<tr>
<td></td>
<td>1.36~1.39</td>
<td>2</td>
<td></td>
<td>Cirrus</td>
</tr>
<tr>
<td></td>
<td>1.58~1.64</td>
<td>2</td>
<td>S/N≥200 (ρ=100%)</td>
<td>Cloud, Snow</td>
</tr>
<tr>
<td></td>
<td>2.10~2.35</td>
<td>2~4</td>
<td></td>
<td>Cirrus, Aerosol</td>
</tr>
<tr>
<td>Middle-wave IR</td>
<td>3.50~4.00</td>
<td>2</td>
<td>NEΔT≤0.7K(300K)</td>
<td>Fire</td>
</tr>
<tr>
<td></td>
<td>3.50~4.00</td>
<td>4</td>
<td>NEΔT≤0.2K(300K)</td>
<td>Land surface</td>
</tr>
<tr>
<td></td>
<td>5.80~6.70</td>
<td>4</td>
<td>NEΔT≤0.3K(260K)</td>
<td>WV</td>
</tr>
<tr>
<td></td>
<td>6.90~7.30</td>
<td>4</td>
<td>NEΔT≤0.3K(260K)</td>
<td>WV</td>
</tr>
<tr>
<td>Long-wave Infrared</td>
<td>8.00~9.00</td>
<td>4</td>
<td>NEΔT≤0.2K(300K)</td>
<td>WV, Clouds</td>
</tr>
<tr>
<td></td>
<td>10.3~11.3</td>
<td>4</td>
<td>NEΔT≤0.2K(300K)</td>
<td>SST</td>
</tr>
<tr>
<td></td>
<td>11.5~12.5</td>
<td>4</td>
<td>NEΔT≤0.2K(300K)</td>
<td>SST</td>
</tr>
<tr>
<td></td>
<td>13.2~13.8</td>
<td>4</td>
<td>NEΔT≤0.5K(300K)</td>
<td>Clouds, WV</td>
</tr>
</tbody>
</table>

### AGRI’s Main Usage:
Acquire multiple band, high temporal resolution, high radiation accuracy images of Earth’s surface, atmosphere and cloud

### GIIRS’s Main Usage:
Acquire atmospheric temperature and humidity profile structures under clear condition

### LMI’s Main Usage:
Acquire lightning distribution maps for a certain coverage

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial resolution</td>
<td>about 7.8Km at SSP</td>
</tr>
<tr>
<td>Sensor size</td>
<td>400×300 ×2</td>
</tr>
<tr>
<td>Wave-length at center</td>
<td>777.4nm</td>
</tr>
<tr>
<td>Band-width</td>
<td>1nm±0.1nm</td>
</tr>
<tr>
<td>Detection efficiency</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>False-alarm ratio</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>&gt;100</td>
</tr>
<tr>
<td>SNR</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Frequency of frames</td>
<td>2ms</td>
</tr>
<tr>
<td>Quantization</td>
<td>12 bits</td>
</tr>
<tr>
<td>Measurement Error</td>
<td>10%</td>
</tr>
</tbody>
</table>

### Spectral Parameters (Normal mode)

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWIR: 700-1130 cm⁻¹</td>
<td>0.8</td>
<td>538</td>
</tr>
<tr>
<td>S/MIR: 1650-2250 cm⁻¹</td>
<td>1.6</td>
<td>375</td>
</tr>
<tr>
<td>VIS : 0.55-0.75 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LWIR/MWIR : 16 Km SSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIS : 2 Km SSP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China area</td>
<td>5000 × 5000 Km²</td>
<td></td>
</tr>
<tr>
<td>Mesoscale area</td>
<td>1000 × 1000 Km²</td>
<td></td>
</tr>
<tr>
<td>China area</td>
<td>&lt;1 hr</td>
<td></td>
</tr>
<tr>
<td>Mesoscale area</td>
<td>&lt;½ hr</td>
<td></td>
</tr>
<tr>
<td>LWIR: 0.5-1.1</td>
<td>S/MIR: 0.1-0.14</td>
<td></td>
</tr>
<tr>
<td>VIS: S/N&gt;200 (ρ=100%)</td>
<td>1.5 K (3σ) radiation</td>
<td></td>
</tr>
<tr>
<td>Calibration accuracy</td>
<td>10 ppm (3σ) spectrum</td>
<td></td>
</tr>
<tr>
<td>Calibration accuracy</td>
<td>13 bits</td>
<td></td>
</tr>
</tbody>
</table>
Use of Radio Spectrum for CMA current and future Metsat systems

FY-4 new products are compared with FY-2

<table>
<thead>
<tr>
<th>Products of FY-4 and FY-2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY-2 Products</td>
</tr>
<tr>
<td>Cloud detection</td>
</tr>
<tr>
<td>Cloud classification</td>
</tr>
<tr>
<td>Total cloud amount</td>
</tr>
<tr>
<td>Precipitation estimation</td>
</tr>
<tr>
<td>Atmospheric motion vector</td>
</tr>
<tr>
<td>Outgoing longwave radiation</td>
</tr>
<tr>
<td>Blackbody brightness temperature</td>
</tr>
<tr>
<td>Surface solar irradiance</td>
</tr>
<tr>
<td>Humidity product analyzed by cloud information</td>
</tr>
<tr>
<td>Total precipitable water</td>
</tr>
<tr>
<td>Upper-atmospheric humidity</td>
</tr>
<tr>
<td>Dust detection</td>
</tr>
<tr>
<td>Sea surface temperature</td>
</tr>
<tr>
<td>Snow cover</td>
</tr>
<tr>
<td>Land surface temperature</td>
</tr>
<tr>
<td>Cloud-top temperature</td>
</tr>
<tr>
<td>Cloud-top height</td>
</tr>
<tr>
<td>Cloud-top pressure</td>
</tr>
<tr>
<td>Cloud optical depth</td>
</tr>
<tr>
<td>Cloud liquid water</td>
</tr>
<tr>
<td>Cloud particle size distribution</td>
</tr>
<tr>
<td>Cloud phase</td>
</tr>
<tr>
<td>Downward longwave radiation: surface</td>
</tr>
<tr>
<td>Upward longwave radiation: surface</td>
</tr>
<tr>
<td>Reflected shortwave radiation: top of atmosphere</td>
</tr>
<tr>
<td>Aerosol optical depth</td>
</tr>
<tr>
<td>Convective initiation</td>
</tr>
<tr>
<td>Firehot spot characterization</td>
</tr>
<tr>
<td>Fog detection</td>
</tr>
<tr>
<td>Land surface emissivity</td>
</tr>
<tr>
<td>Land surface temperature</td>
</tr>
<tr>
<td>Land surface albedo</td>
</tr>
<tr>
<td>Tropopause folding turbulence prediction</td>
</tr>
<tr>
<td>Legacy vertical temperature profile</td>
</tr>
<tr>
<td>Ozone profile and total</td>
</tr>
<tr>
<td>Atmospheric instability index</td>
</tr>
<tr>
<td>Lightning detection</td>
</tr>
<tr>
<td>Space and solar products</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Y-4A (experimental)</th>
<th>FY-4 (operational)</th>
<th>FY-2 (operational)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilization</td>
<td>Three axis</td>
<td>Three axis</td>
</tr>
<tr>
<td>Designed life</td>
<td>7 years (designed life)</td>
<td>7 years (operation life)</td>
</tr>
<tr>
<td>Observation efficiency</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td>Observation mode</td>
<td>Imaging + sounding + lightning mapping</td>
<td>Imaging + sounding + lightning mapping</td>
</tr>
<tr>
<td></td>
<td>14 channels</td>
<td>18 channels</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.5–4 km</td>
<td>0.5–2 km</td>
</tr>
<tr>
<td>Full disc</td>
<td>15 min</td>
<td>5 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area coverage</td>
<td>7.8 km</td>
<td>Full-disc coverage</td>
</tr>
<tr>
<td>SSP resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-energy particles</td>
<td>Magnetic field</td>
<td>High-energy particles, magnetic field, solar imager</td>
</tr>
<tr>
<td>SEP</td>
<td></td>
<td></td>
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<tr>
<td>Magnetic field</td>
<td></td>
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<tr>
<td>SEM</td>
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<tr>
<td>High-energy particles</td>
<td>Solar X-ray fluxes</td>
<td></td>
</tr>
</tbody>
</table>

Reference:

Jun Yang., 2017: INTRODUCING THE NEW GENERATION OF CHINESE GEOSTATIONARY WEATHER SATELLITES, FENGYUN-4, BAMS, 1637-1658
FY-4 will improve most products of FY-2 and introduce many new products, such as atmospheric temperature and moisture profiles, atmospheric instability index, layer perceptible water vapor, and rapidly developing clouds, and others.

FY-4 products are expected to provide enhanced applications and services.

The FY-4 GIIRS is one of the Group on Earth Observations (GEO) sounders planned by Global Earth Observation System of systems (GEOSS) member states in response to the call from the WMO for advanced sounders in the geostationary orbit.

FY-4 will become an important GEO component of the global Earth-observing system.
Use of Radio Spectrum for CMA current and future Metsat systems

FY-4A Ground Segment

Level 1: Reconstructed, unprocessed instrument data at full resolution, including radiometric and geometric calibration, coefficients and georeferencing parameters.
Level 2: Derived meteorological, physical, environmental and space-weather variables from L1 data.
Level 3: The average or other statistical results from L2 data.
DCP: Data Collection Platform
DCPR: Data Collection Platform Report
Primary ground missions as follows:

1) Receiving raw data from the satellite;
2) Determining and predicting the satellite orbit based on ranging measurements to the satellite;
3) Monitoring the satellite and controlling the payloads;
4) Undertaking the mission management and operation control of the satellite and ground systems;
5) Processing data for geolocation and registration;
6) Processing data for measurement calibration;
7) Producing quantitative products;
8) Providing an archive and distribution service for the data and products;
9) Carrying out applications for the weather, climate and environment;
10) Accomplishing monitoring and predicting services for space weather.
FY-4A data distribution and applications
THE FIRST IMAGES FROM THE AGRI OF FY-4A
<table>
<thead>
<tr>
<th>Year</th>
<th>FY-2H</th>
<th>FY-4B</th>
<th>FY-4C</th>
<th>FY-4MW</th>
<th>FY-4D</th>
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<tbody>
<tr>
<td>2015</td>
<td></td>
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<td>2016</td>
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<td>2018</td>
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<td>2024</td>
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<td>2025</td>
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</table>

Use of Radio Spectrum for CMA current and future Metsat systems

CMA, WMO/ITU Seminar, 23-24 October 2017
1.2 FENGYUN  Polar Constellation

In operation: FY-3B (global) + FY-3C (global) + FY-3A (regional)

- FY-3C  LTC 10:20 AM
- FY-3B  LTC 13:40 PM
The second polar orbit generation: FY-3

- 11 instruments
  - Atmospheric sounding
  - Microwave Imaging
  - Ozone sounding
  - Radiation budget for Earth system
- Spatial Resolution from Km to 250m

Compared with the FY-1 satellite, the FY-3 satellite is more capable in many terms:

- Vertical temperature and humidity sounding,
- Ozone detection
- Microwave sensor
- Visible,
- Infrared imaging.
Use of Radio Spectrum for CMA current and future Metsat systems

Global Data Latency within 4 hours maximum

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing Station</td>
<td>116° 16' 36&quot; E</td>
<td>40° 03' 06&quot; N</td>
</tr>
<tr>
<td>Guangzhou Station</td>
<td>113° 20' 20&quot; E</td>
<td>23° 09' 52&quot; N</td>
</tr>
<tr>
<td>Wulumuqi Station</td>
<td>87° 34' 08&quot; E</td>
<td>43° 52' 17&quot; N</td>
</tr>
<tr>
<td>Jiamusi Station</td>
<td>130° 22' 48&quot; E</td>
<td>46° 45' 20&quot; N</td>
</tr>
<tr>
<td>Kiruna Station</td>
<td>21° 02' E</td>
<td>67° 32' N</td>
</tr>
</tbody>
</table>
Use of Radio Spectrum for CMA current and future Metsat systems

FY-3B Global Image 20110827——Typhoon Talas, Nanmadol and Hurricane Irene
Use of Radio Spectrum for CMA current and future Metsat systems

FENGYUN future LEO Satellites Launch Plan by 2025

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<td>FY-3D</td>
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<tr>
<td>FY-3E</td>
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<td>FY-3F</td>
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<tr>
<td>FY-3R</td>
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<tr>
<td>FY-3G</td>
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<tr>
<td>FY-3 EM</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

FY-3 Afternoon
1.3 CURRENT CMA RECEIVED OTHER SATELLITES

1) GF-4
   - The 4th satellite in High res. Earth Obs, Satellite Project led by CNSA.
   - Successfully launched in Dec. 29, 2015
   - Commissioning test finished and handover declared on June 1st, 2016
   - CMA is responsible for GF-4 data reception and transmission, as well as data preprocessing in MET mode.

2) TANSAT
   - Launched in Dec. 22, 2016
   - A joint research & development satellite program initiated by MOST (Ministry of Science and Technology) and supported by CMA and CAS (Chinese Academy of Sciences).
   - CMA is responsible for data reception, processing and distribution, taking advantage of current FY-3 earth station resources.
1.4 Space Weather

- In 2002, CMA was authorized by the National Council to establish the National Center for Space Weather (NCSW), assigned to the National Satellite Meteorological Center.

- NCSW began to provide space weather operational service On July 1, 2004.

- NCSW now has preliminary developed a complete operation system covering space weather monitor, forecast, and service.

Missions of NCSW

- To study and draft strategy and development programs for China’s Space weather operations.
- To build up space-based and ground-based monitoring systems for China’s space weather operations.
- To be responsible for receiving, processing, distributing and studying space weather data.
- To provide space weather monitoring and warning operations and services
The FY satellites have been playing an important role in space weather observations

- **The Polar satellites** could monitor impacts of energetic particles. The FY-3C could give the ionosphere information by GNSS radio occultation receiver.

- **The Geo. satellites** could measure solar X-ray and energetic particles. FY-4 will provide the solar imaging and geomagnetic field observations.
2 Applications

Weather

Climate

Resource

Disaster

Environment
Use of Radio Spectrum for CMA current and future Metsat systems

Typhoon

Sand Storm

Fire monitor

Heat

Blue-green alga
Use of Radio Spectrum for CMA current and future Metsat systems

Haze and PM2.5

- Aerosol
- NO2
- CO2
- CH4
- SO2
Use of Radio Spectrum for CMA current and future Metsat systems

Snow Cover

2022 Winter Olympics, Yanqing and Zhangjiakou
3、Data and Products Service

- Long-term historic satellite data since 1984, over 600 TeraByte
Use of Radio Spectrum for CMA current and future Metsat systems

Access to Satellite Data and Products

1) Web-based Service (register user)
2) CMACast (register user)
3) FTP Push (important user)
4) FTP Pull (register user)
5) Manual Service (emergency)
6) DB Users (register user)
7) Cloud service mode for FY-4 data application (all users)

http://satellite.cma.gov.cn
CMACast

CMACast is based on DVB-S2 technology with both file and multimedia transmission capability. It uses an entire 36MHz C-band transponder of communication satellite to distribute meteorological data and satellite sensing data to users of Asia-Pacific region.

CMACast in GEONETCast

CMACast

EUMETCast

CMACast

NOAACast

CMACast Hub

AsiaSat-4

C-band

Exchanged data from EUMETCast

Exchanged data from GEONETCast Americas

Products

Space-based observation data

Land-based observation data

Air-based observation data

Common Users

Asia Pacific

CMA
4、Use of Radio Spectrum

4.1 FY-2


General objective: Chinese first generation geostationary meteorological satellite systems.


Orbit: GEO (86.5E, 99.5E, 105E, 112E and 123.5E)

Main earth station(s): Beijing, Guangzhou, Xinjiang (China)

Service frequencies: See below table.
<table>
<thead>
<tr>
<th>Frequency range (MHz)</th>
<th>Emission</th>
<th>Bandwidth (MHz)</th>
<th>Direction</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1671.6-1691.6</td>
<td>20M0G1D--</td>
<td>20</td>
<td>S-E</td>
<td>CDAS</td>
</tr>
<tr>
<td>2046.5-2048.5</td>
<td>2M00G1D--</td>
<td>2</td>
<td>E-S</td>
<td>S-VISSR</td>
</tr>
<tr>
<td>1686.5-1688.5</td>
<td>2M00G1D--</td>
<td>2</td>
<td>S-E</td>
<td>S-VISSR</td>
</tr>
<tr>
<td>2050.87-2051.13</td>
<td>260KFXD--</td>
<td>0.26</td>
<td>E-S</td>
<td>LRIT</td>
</tr>
<tr>
<td>1690-1691</td>
<td>1M00G2W--</td>
<td>1</td>
<td>S-E</td>
<td>LRIT</td>
</tr>
<tr>
<td>1690.87-1691.13</td>
<td>260KFXD--</td>
<td>0.26</td>
<td>S-E</td>
<td>WEFAX</td>
</tr>
<tr>
<td>401.1-401.4</td>
<td></td>
<td>0.3</td>
<td>E-S</td>
<td>DCP</td>
</tr>
<tr>
<td>402.0-402.1</td>
<td></td>
<td>0.1</td>
<td>E-S</td>
<td>DCP</td>
</tr>
<tr>
<td>2059.487-2059.513</td>
<td>26K0FXD--</td>
<td>0.026</td>
<td>E-S</td>
<td>S-WEFAX</td>
</tr>
<tr>
<td>1699.487-1699.513</td>
<td>26K0FXD--</td>
<td>0.026</td>
<td>S-E</td>
<td>S-WEFAX</td>
</tr>
<tr>
<td>2050-2051</td>
<td>1M00G2W--</td>
<td>1</td>
<td>E-S</td>
<td>Ranging</td>
</tr>
<tr>
<td>1690-1691</td>
<td>1M00G2W--</td>
<td>1</td>
<td>S-E</td>
<td>Ranging</td>
</tr>
<tr>
<td>2046-2047</td>
<td>1M00G2W--</td>
<td>1</td>
<td>E-S</td>
<td>Ranging</td>
</tr>
<tr>
<td>1686-1687</td>
<td>1M00G2W--</td>
<td>1</td>
<td>S-E</td>
<td>Ranging</td>
</tr>
<tr>
<td>2044-2045</td>
<td>1M00G2W--</td>
<td>1</td>
<td>E-S</td>
<td>Ranging</td>
</tr>
<tr>
<td>1684-1685</td>
<td>1M00G2W--</td>
<td>1</td>
<td>S-E</td>
<td>Ranging</td>
</tr>
</tbody>
</table>
4.2 FY-3

Mission name: FY-3 series
General objective: Chinese second generation non-geostationary meteorological satellite systems.
ITU filing name: FY-3, FY-3-A
Launch Date: FY-3A, FY-3B and FY-3C of FY-3 series were launched on 27 May 2008, 5 November 2010 and 23 September 2014 respectively, FY-3D will be launched on Second half of 2017.
Orbit: Polar orbiting satellite, Apogee: 854km, Perigee: 818km
Service frequencies: L, S and X bands.
Local time of descending node: 1) FY-3A and FY-3C:10:00-10:20; 2) FY-3B and FY-3D:13:40-14:00.
Main earth station(s): Beijing, Guangzhou, Xinjiang, Jiamusi(China), Kiruna(Sweden).
1) Data transmission

<table>
<thead>
<tr>
<th>Missions</th>
<th>Frequency (MHz)</th>
<th>Emission</th>
<th>Bandwidth (MHz)</th>
<th>Direction</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY-3A/FY-3B</td>
<td>1704.5</td>
<td>6M80G1W--</td>
<td>6.8</td>
<td>S-E</td>
<td>HRPT</td>
</tr>
<tr>
<td></td>
<td>7775</td>
<td>45M0G1W--</td>
<td>45</td>
<td>S-E</td>
<td>MPT</td>
</tr>
<tr>
<td></td>
<td>8145.95</td>
<td>149MG1W--</td>
<td>149</td>
<td>S-E</td>
<td>DPT</td>
</tr>
<tr>
<td>FY-3C</td>
<td>1701.4</td>
<td>6M80G1W--</td>
<td>6.8</td>
<td>S-E</td>
<td>HRPT</td>
</tr>
<tr>
<td></td>
<td>7780</td>
<td>60M0G1W--</td>
<td>60</td>
<td>S-E</td>
<td>MPT</td>
</tr>
<tr>
<td></td>
<td>8175</td>
<td>300MG1W--</td>
<td>300</td>
<td>S-E</td>
<td>DPT</td>
</tr>
<tr>
<td>FY-3D</td>
<td>1706.7</td>
<td>6M80G1W--</td>
<td>6.8</td>
<td>S-E</td>
<td>HRPT</td>
</tr>
<tr>
<td></td>
<td>7820</td>
<td>60M0G1W--</td>
<td>60</td>
<td>S-E</td>
<td>MPT</td>
</tr>
<tr>
<td></td>
<td>8250</td>
<td>300MG1W--</td>
<td>300</td>
<td>S-E</td>
<td>DPT</td>
</tr>
</tbody>
</table>
## 2) Passive sensor

<table>
<thead>
<tr>
<th>Payload name</th>
<th>Frequency (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave Radiation Imager MWRI</td>
<td>18.6-18.8, 23.6-24, 36-37, 86-90</td>
</tr>
<tr>
<td>Microwave Temperature Sounder</td>
<td>50.2-50.4, 51.56-51.96, 52.6-53, 54.2-54.6, 55.3-55.7, 53.396-53.566,</td>
</tr>
<tr>
<td></td>
<td>54.740-55.140, 57.125-57.455</td>
</tr>
<tr>
<td>Microwave Humidity Sounder</td>
<td>89, 150; 113.75, 123.75, 176.31, 178.81, 187.81, 190.31;</td>
</tr>
<tr>
<td></td>
<td>115.75, 121.75, 180.31, 186.31; 181.51, 185.11; 182.31, 184.31;</td>
</tr>
<tr>
<td></td>
<td>116.25, 117.65, 117.95, 119.55, 119.85, 121.25; 118.45, 119.05;</td>
</tr>
<tr>
<td></td>
<td>118.55, 118.95; 118.67, 118.83;</td>
</tr>
</tbody>
</table>

## 3) Active sensor

<table>
<thead>
<tr>
<th>Payload name</th>
<th>Frequency center / bandwidth GHz</th>
<th>Frequency band (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation measurement radar, PMR</td>
<td>13.6/0.0006</td>
<td>13.5997-13.6003</td>
</tr>
<tr>
<td></td>
<td>35.75/0.5</td>
<td>35.5-36</td>
</tr>
<tr>
<td>Wind radar, WMFR-C</td>
<td>5.41/0.32</td>
<td>5.25-5.57</td>
</tr>
<tr>
<td></td>
<td>5.3/0.02</td>
<td>5.29-5.31</td>
</tr>
<tr>
<td>Wind radar, WMFR-KU</td>
<td>13.5/0.5</td>
<td>13.25-13.75</td>
</tr>
<tr>
<td></td>
<td>13.276/0.02</td>
<td>13.266-13.286</td>
</tr>
</tbody>
</table>
4.3 FY-4

Mission name: FY-4 series

General objective: Chinese second generation geostationary meteorological satellite systems.

Launch Date: The FY-4A was launched in 11Dec 2016, the second satellite, FY-4B, will be launched in year 2019.

ITU filing name: FYGEOSAT-99.5E/-A-99.5E, FYGEOSAT-105E/-A-105E.


Main earth station(s): Beijing, Guangzhou, Xinjiang and Zhangjiakou or Chengde(China); Zhangjiakou or Chengde station is under considering.

Service frequencies: Frequencies, bandwidth and direction of missions for FY-4 missions are listed in the bellow table.
1) Data transmission

<table>
<thead>
<tr>
<th>Frequency range (MHz)</th>
<th>Direction</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>401.1-401.4</td>
<td>E-S</td>
<td>DCP</td>
</tr>
<tr>
<td>402.0-402.1</td>
<td>E-S</td>
<td>DCP</td>
</tr>
<tr>
<td>1675-1690</td>
<td>S-E</td>
<td>HRIT/DCPR</td>
</tr>
<tr>
<td>1690-1696</td>
<td>S-E</td>
<td>Ranging</td>
</tr>
<tr>
<td>1696-1698</td>
<td>S-E</td>
<td>LRIT/EWAIB</td>
</tr>
<tr>
<td>2056.5~2057.5</td>
<td>E-S</td>
<td>LRIT</td>
</tr>
<tr>
<td>2042-2052</td>
<td>E-S</td>
<td>Ranging</td>
</tr>
<tr>
<td>2222-2232</td>
<td>S-E</td>
<td>Ranging</td>
</tr>
<tr>
<td>7450-7550</td>
<td>S-E</td>
<td>RD</td>
</tr>
<tr>
<td>8175~8215</td>
<td>E-S</td>
<td>HRIT</td>
</tr>
<tr>
<td>18100-18400</td>
<td>S-E</td>
<td>RD</td>
</tr>
<tr>
<td>25500-27000</td>
<td>S-E</td>
<td>RD</td>
</tr>
</tbody>
</table>
Frequency use of future FENGYUN satellites

1) Data transmission
   - Higher frequency, higher bandwidth and higher speed: 25.5-27GHz
   - Data relay: 25.25-27.5GHz

2) Sensor
   - Active: 94GHz
   - Passive: 229GHz, 243GHz, 325GHz, 448GHz, 664GHz
Thanks!