How your weather forecast is made - its dependence on passive microwave data from satellites

Cómo se hacen las predicciones meteorológicas: dependencia de los datos en microondas pasivos procedentes de los satélites

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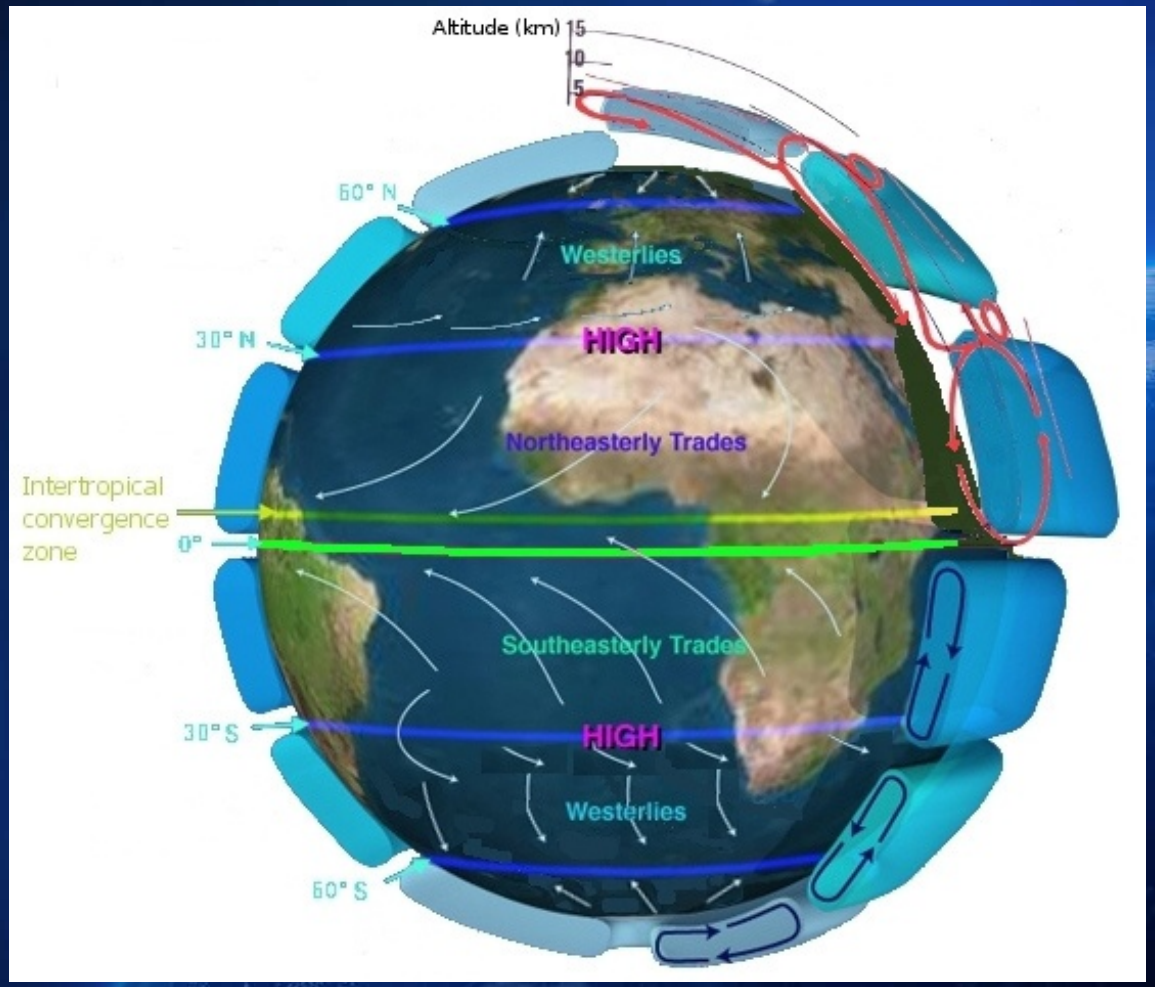
Seminario de la UIT para la Región de las Américas (Manta, Ecuador, 20-21 de septiembre de 2012)
ITU Seminar for Americas Region (Manta, Ecuador, 20-21 September 2012)

Science review

Revision de la Ciencia



Differing science weather forces
Diferentes fuerzas de la ciencia del tiempo

Tropics
- delicate forces
- land-ocean temperature difference
- heat released when clouds form

- Extratropical
  - more obvious forces
  - earth rotation (Coriolis)
  - atmospheric pressure

Trópico
- Delicate forces
- Las fuerzas delicados
- tierra-océano diferencia de temperatura, el calor liberado cuando se forman las nubes

- Extratropical
  - Las fuerzas más evidentes
  - la rotación de la Tierra (Coriolis)
  - la presión atmosférica

How the forecast is made – extratropical
Cómo se hace el pronóstico - extratropical

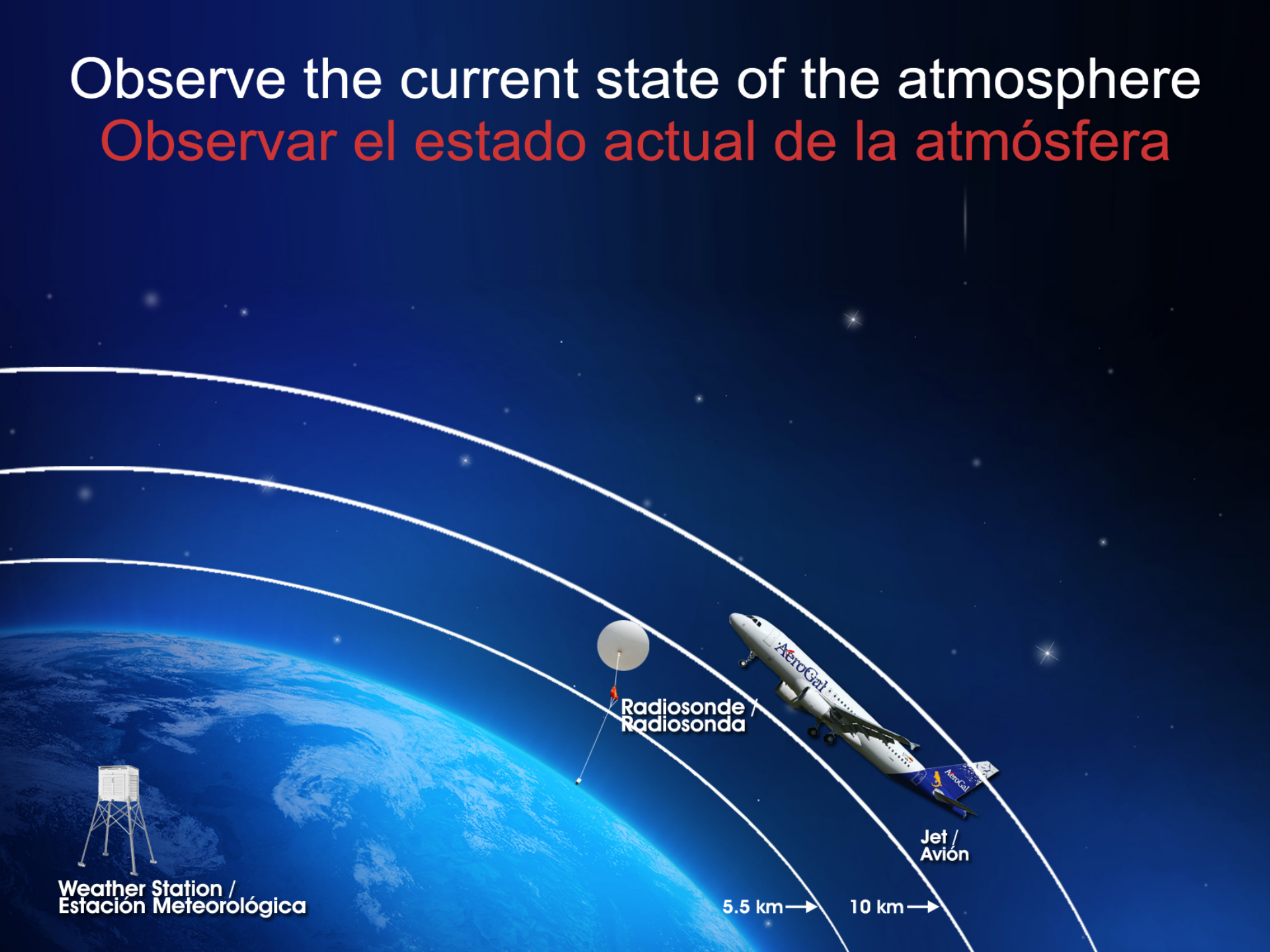
Observe the current state of the atmosphere	Observar el estado actual de la atmósfera
Gather and distribute observed data	Recopilar y distribuir datos observados
Feed data into weather model	Introducir los datos en el modelo de tiempo
Run weather model	Ejecutar modelo meteorológico
Generate weather forecast	Generar pronóstico del tiempo
Distribute weather forecast	Distribuir pronóstico del tiempo

Observe the current state of the atmosphere
Observar el estado actual de la atmósfera

Weather Station /
Estación Meteorológica

Observe the current state of the atmosphere
Observar el estado actual de la atmósfera

Observe the current state of the atmosphere
Observar el estado actual de la atmósfera



Observe the current state of the atmosphere
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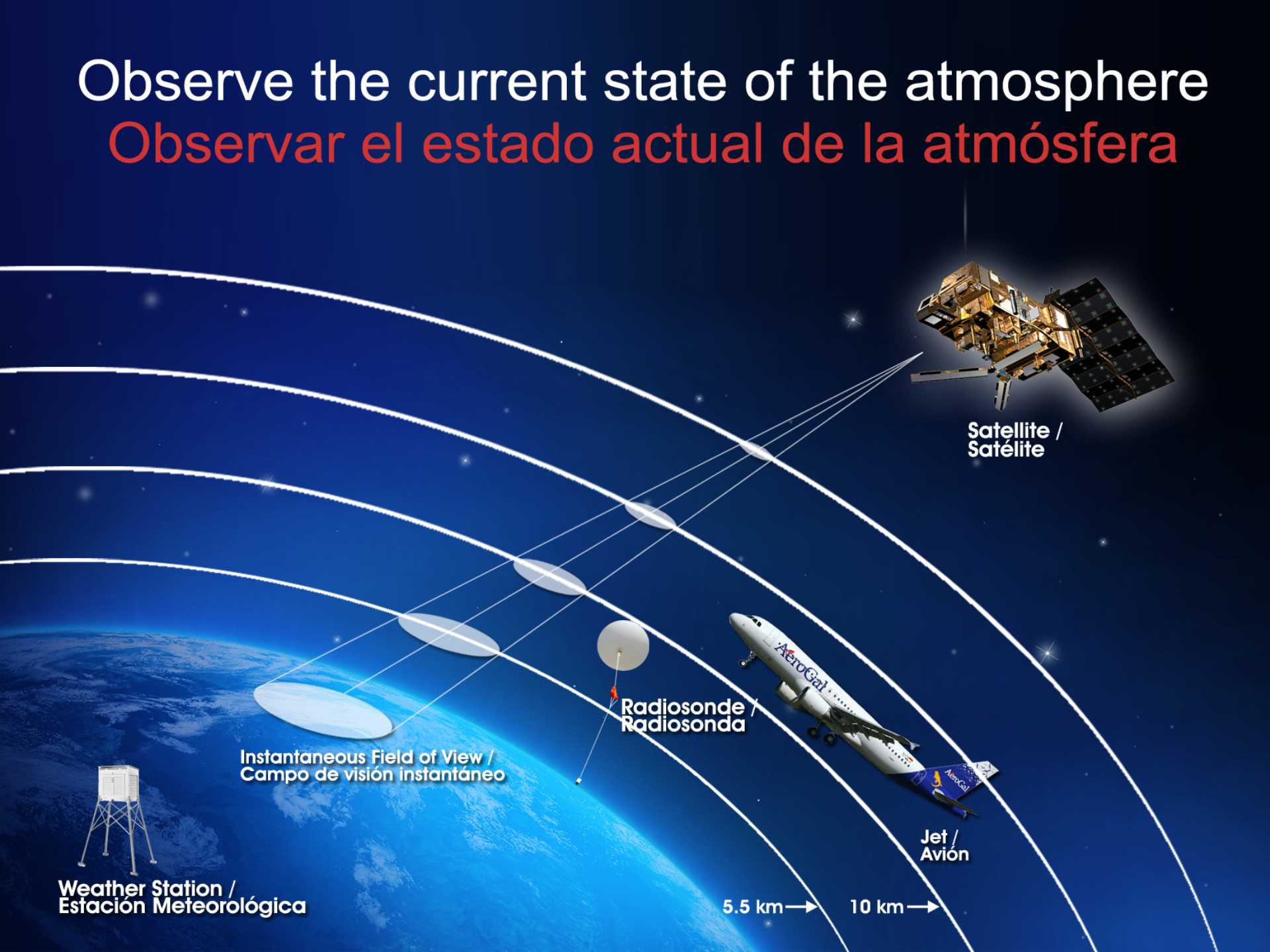


Gather and distribute observed data

via WMO Information System

Recopilar y distribuir datos observados

A través de Sistema de Información de la OMM

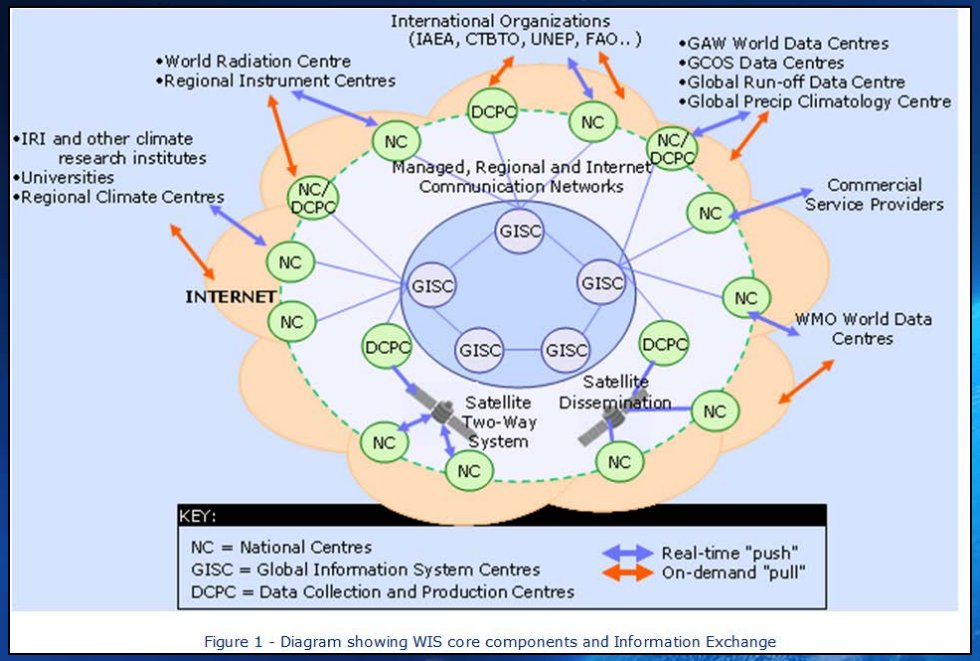
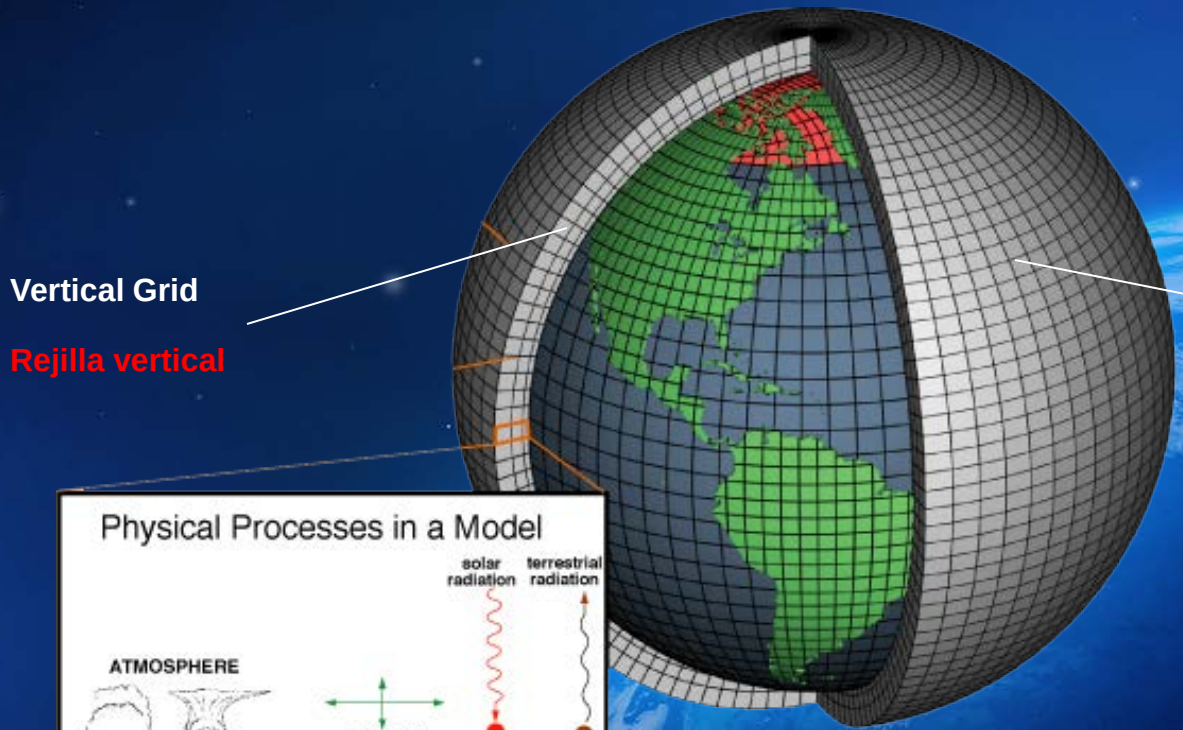


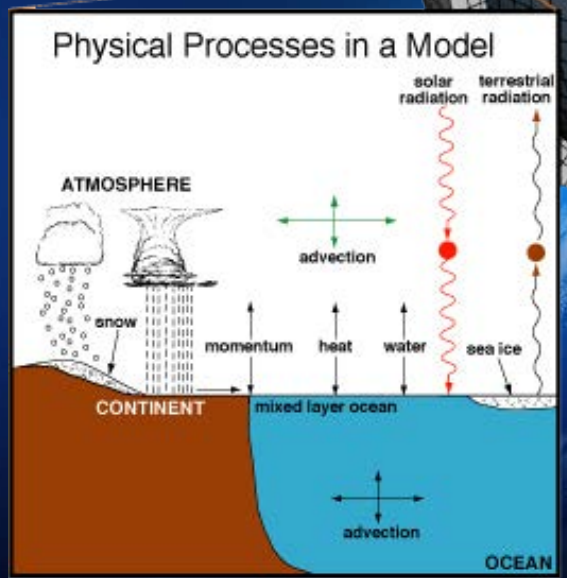
Figure 1 - Diagram showing WIS core components and Information Exchange

- National Centre -
  - numerical weather prediction (NWP)
- Data Collection and Production Centre
  - Example ECMWF
- Centro Nacional de -
  - predicción numérica del tiempo (PNT)
- Recolección de Datos y el Centro de Producción
- Ejemplo ECMWF

Feed data into weather model

Introducir los datos en el modelo de tiempo





Run weather model
Ejecutar modelo meteorológico

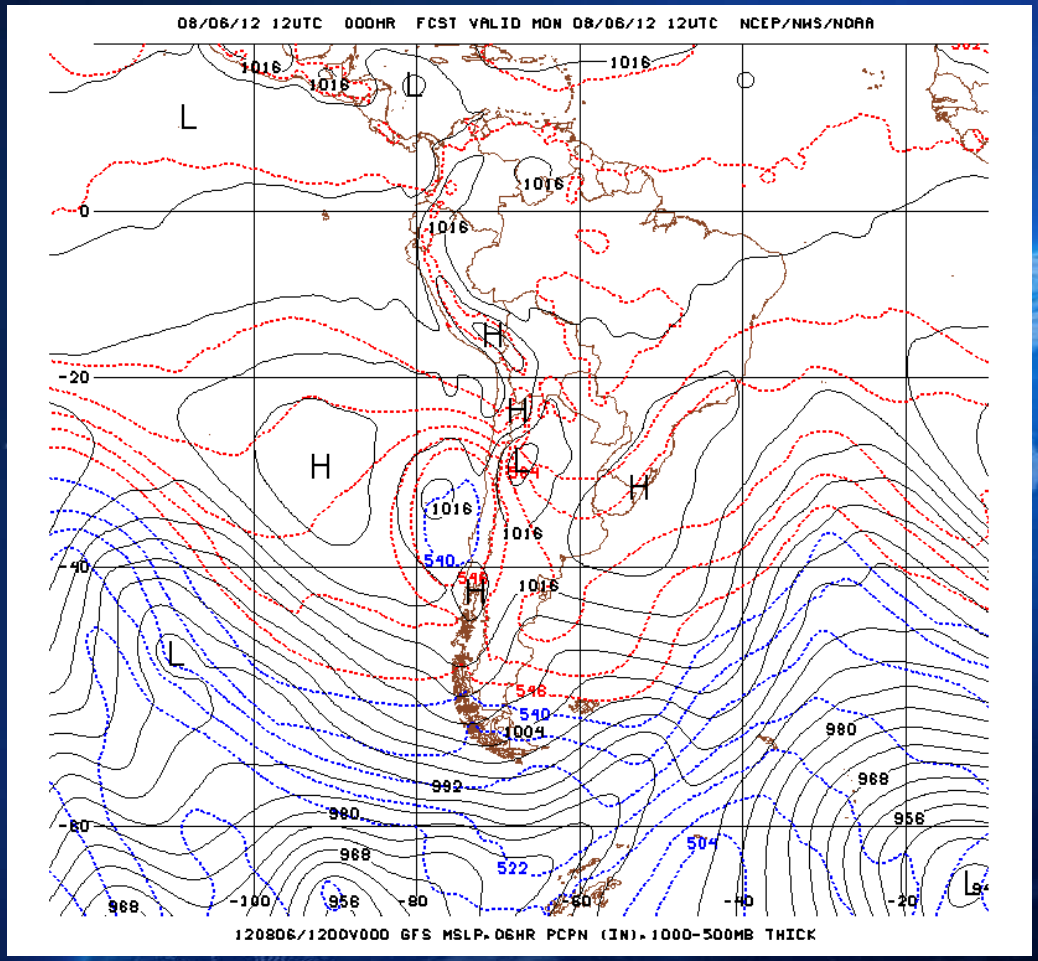
Key elements of NWP system

- Start with analysis
- Forecast weather variables in small time steps
- Follow laws of thermodynamics and chemistry

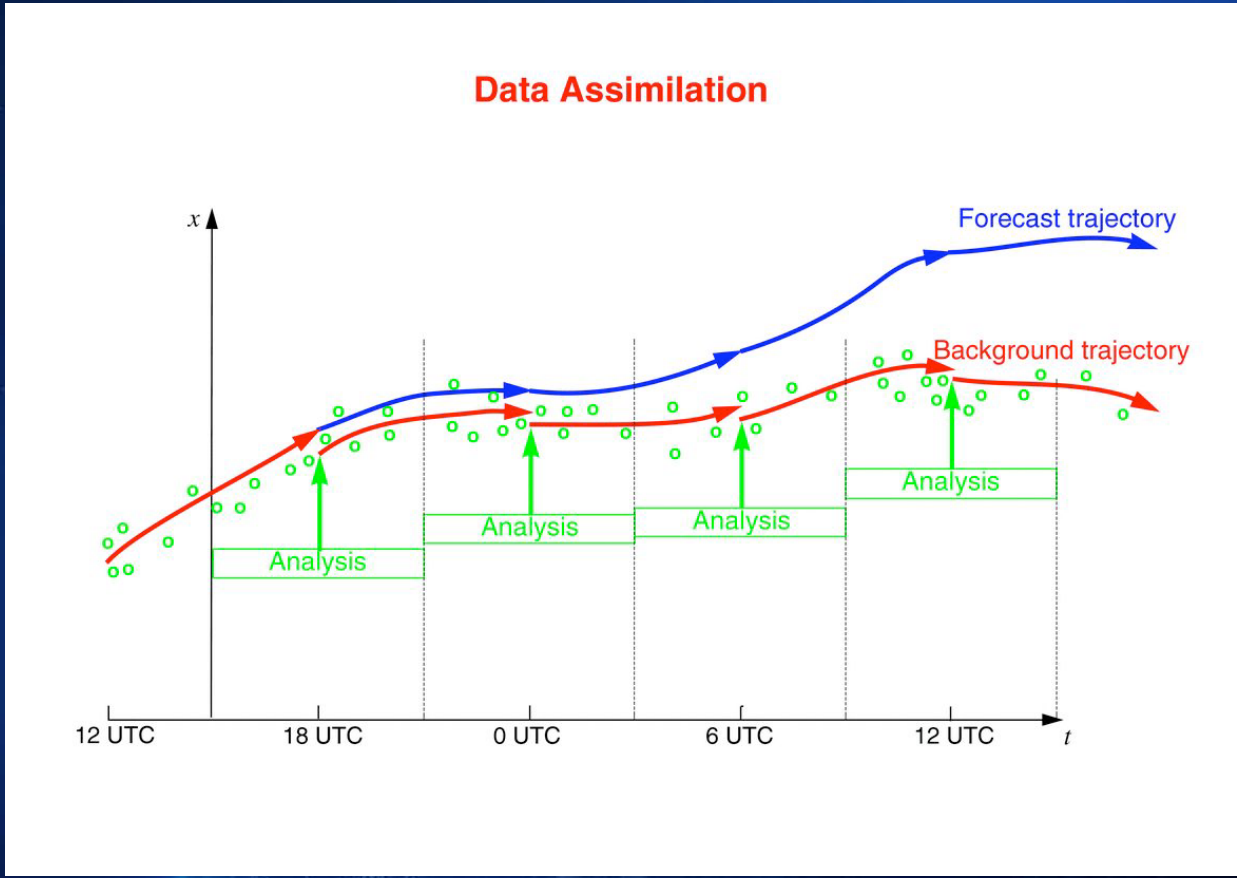
Los elementos clave del sistema de predicción numérica del tiempo

- Comienza con un análisis
- Las variables de pronóstico del tiempo en intervalos de tiempo pequeños
- Cumplir con las leyes de la termodinámica y la química

Analysis
Análisis



Run weather model
Ejecutar modelo meteorológico

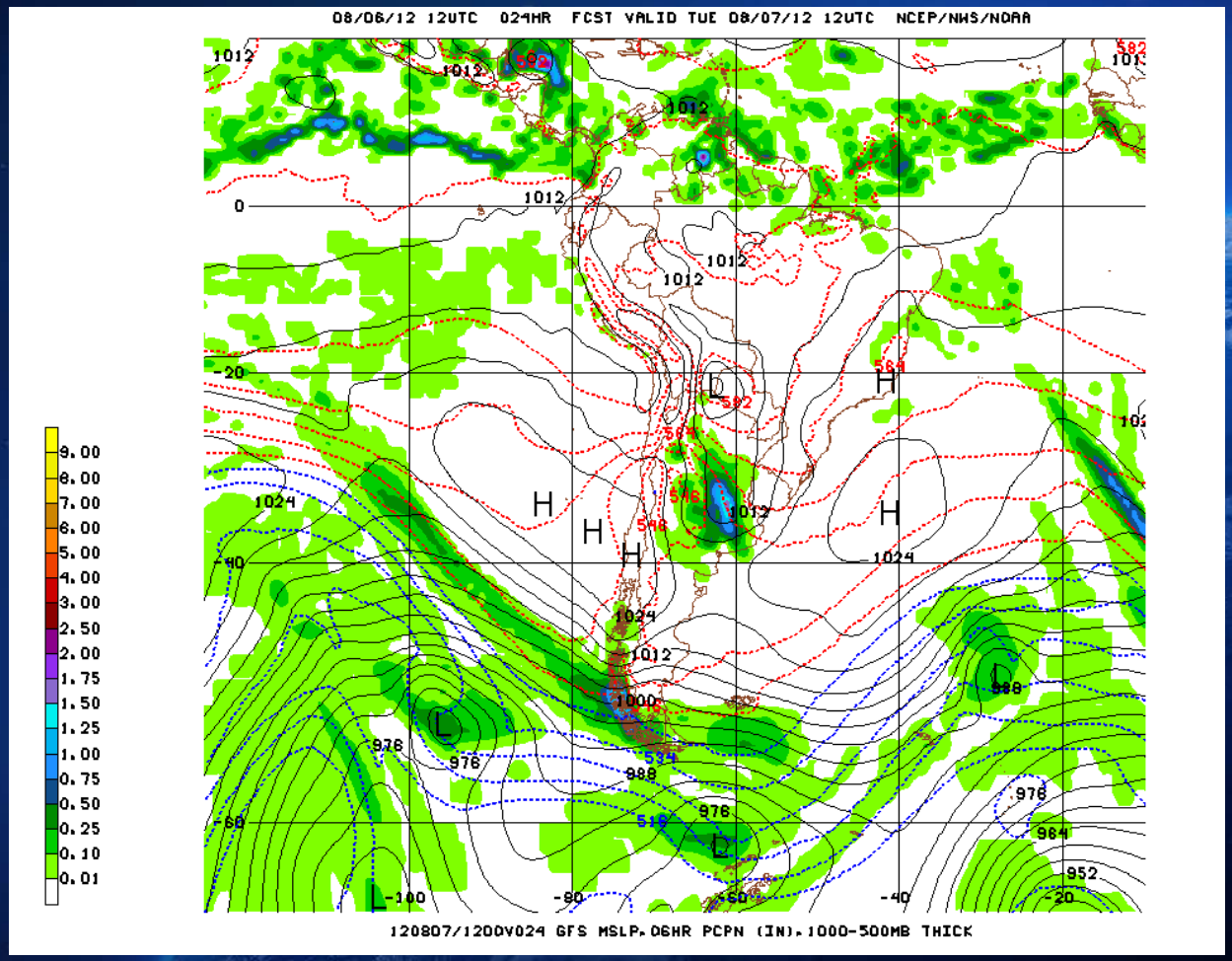


Weather model output
El tiempo en la salida del modelo

- Two types of output
  - Data for the public and forecasters
  - Data to evaluate the weather model
- Dos tipos de salida
  - Los datos para el público y los meteorólogos
  - Los datos para evaluar el modelo meteorológico

Data for the public and forecasters

Los datos para el público y los meteorólogos

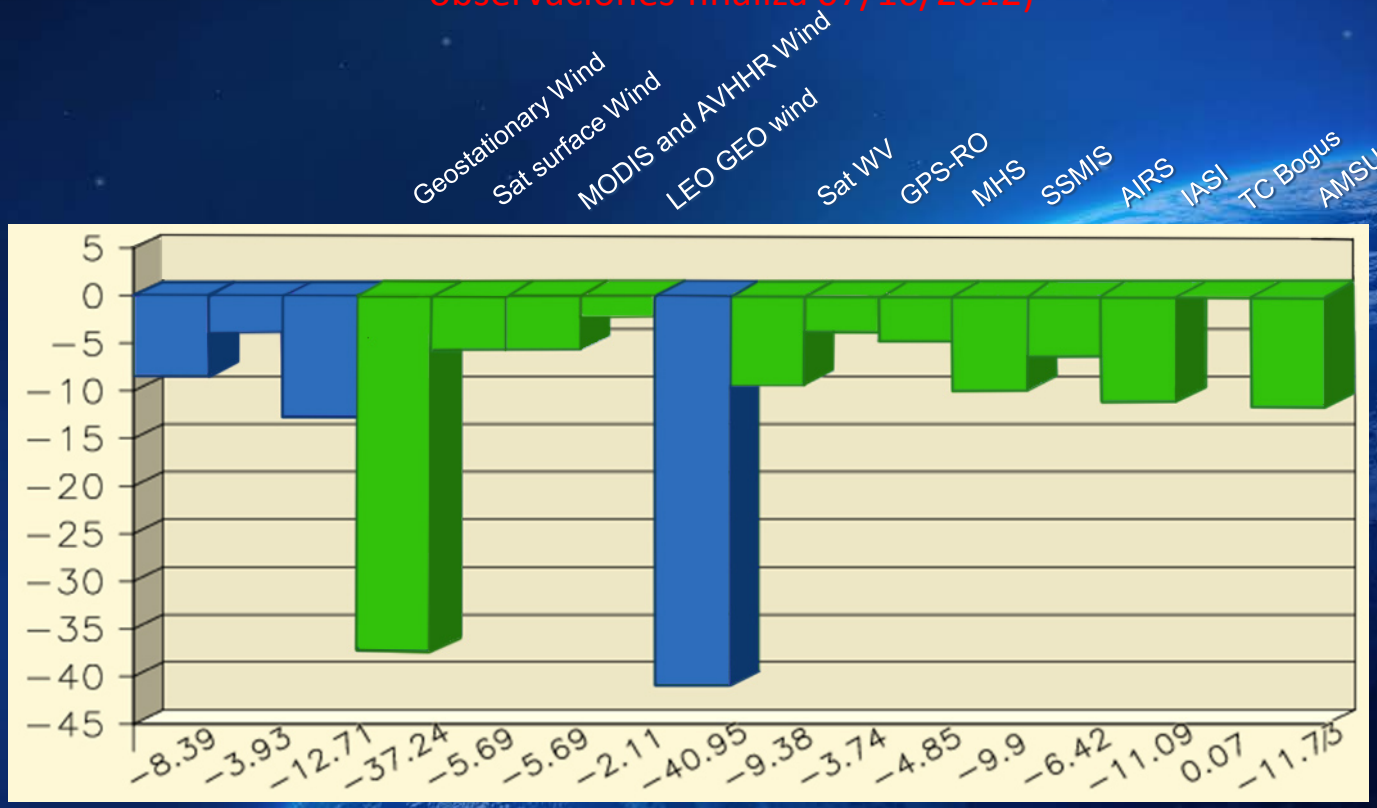


Data to evaluate the weather model

Los datos para evaluar el modelo meteorológico

30 day effects of observations on 24 hour accuracy (00 UTC observations period ending 16.07.2012)

efectos de30 días de observaciones sobre la exactitud de las 24 horas (00 UTC período de observaciones finaliza 07/16/2012)



12 of 16 observation types are made by satellites

12 de 16 tipos de observación son tomadas por los satélites

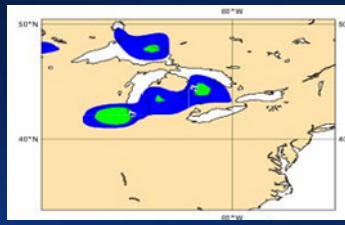
Why satellite observations are important

Por qué son importantes las observaciones por satélite

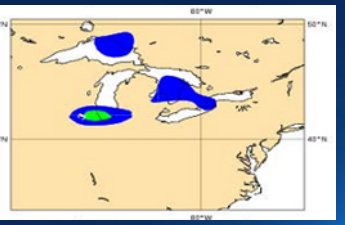
3 day snowfall forecast for 19.12.2009 at 1200UTC - data assimilation system

Pronóstico de 3 días de nevadas en 1200UTC 19/12/2009 - sistema de asimilación de datos

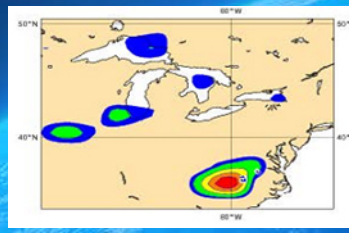
No polar satellites
Sin satélites polares



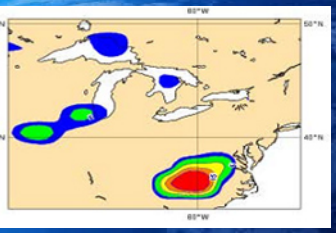
NOAA18/Aqua
NOAA18/Aqua



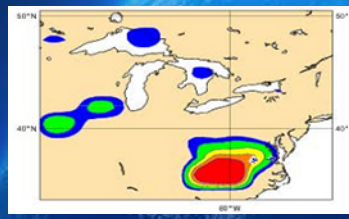
METOP-A only
METOP-A solamente



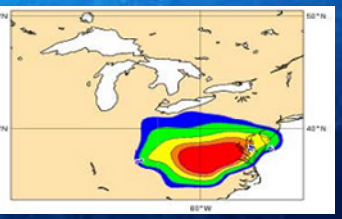
METOP-A and NOAA18/Aqua
METOP-A y NOAA18/Aqua



All data
Todos los datos

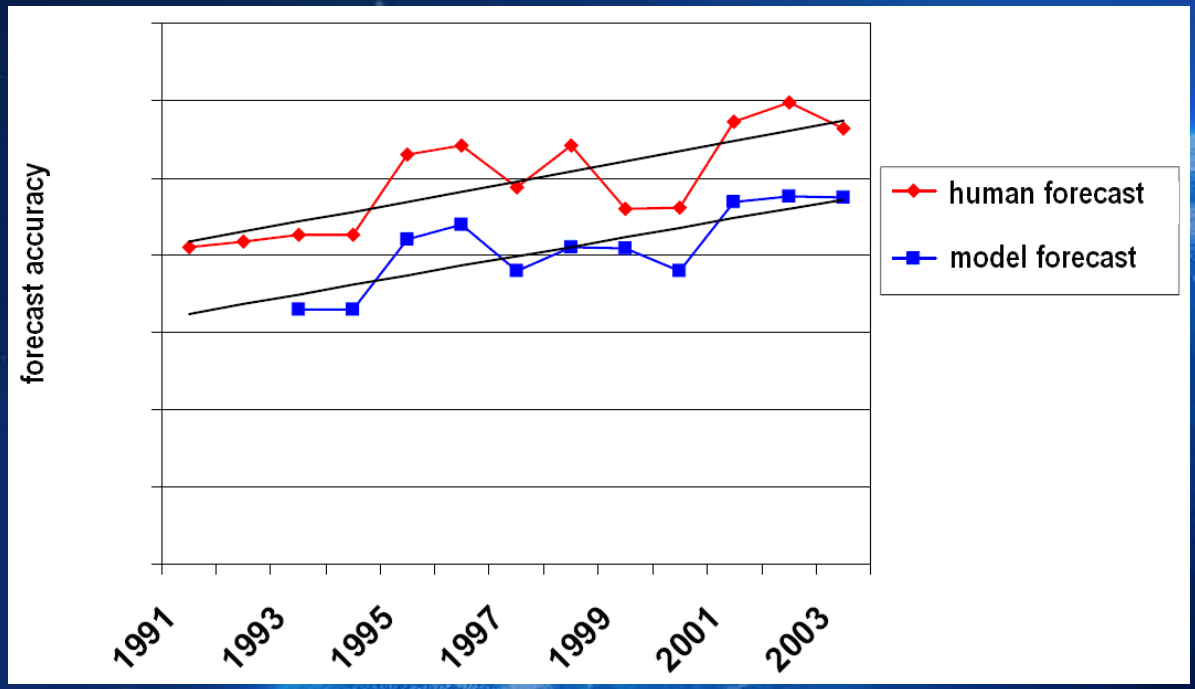


What actually happened
Lo que realmente sucedió



Humans using models improve the forecast

Los seres humanos utilizando los modelos mejoran el pronóstico



Generate Weather Forecast

Generar Pronóstico del Tiempo

A forecaster

- Watches weather using models, analyses, experience
- Diagnoses model errors - adjusts forecast
- Adjusts short term forecast - reflect current conditions
- Modifies long term forecast
- Delivers forecast for dissemination

A forecaster adds value to weather models

Un pronosticador

- Observa tiempo usando modelos, análisis, experiencia
- Encuentra errores en el modelo - Ajusta pronósticos
- Ajusta previsión a corto plazo - refleja las actuales condiciones
- Modifica el pronóstico a largo plazo
- Ofrece previsiones para la difusión

Un meteorólogo añade valor a los modelos climáticos

Distribute weather forecast
Distribuir pronóstico del tiempo

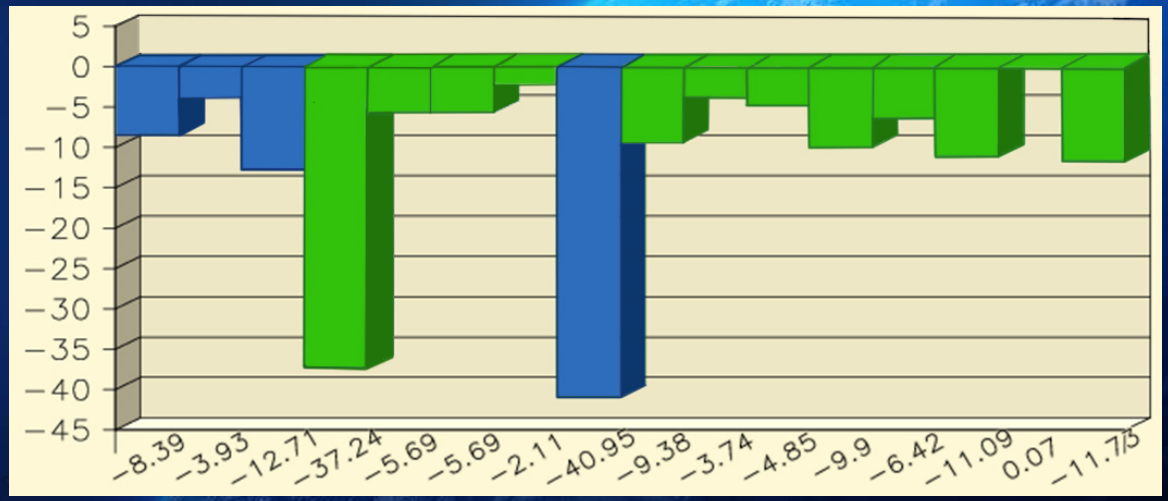
- Forecasts are perishable -> disseminate rapidly
- Disseminate via
  - Point to multipoint (Newspapers, radio, t.v.)
  - Point to point - on demand to one user at a time
  - Other methods – Telephone, fax, email, internet

- Las previsiones son perecederos -> diseminar rápidamente
- Difundir a través de
  - Punto a multipunto (Prensa, radio, televisi-n)
  - Punto a punto - a petición de un usuario a la vez
  - Otros métodos: teléfono, fax, correo electrónico, Internet

Summary
resumen

- Weather models are important to forecasts
- Forecasters add value to models
- Models are heavily dependent on satellite data, 12 of 16 data inputs are from satellite

- Los modelos climáticos son importantes para las previsiones
- Los meteorólogos agregar valor a los modelos
- Los modelos son muy dependientes de los datos de satélite, 12 de 16 entradas de datos son desde el satélite



Backup Slides

Ecuador climate correlated with terrain

climate

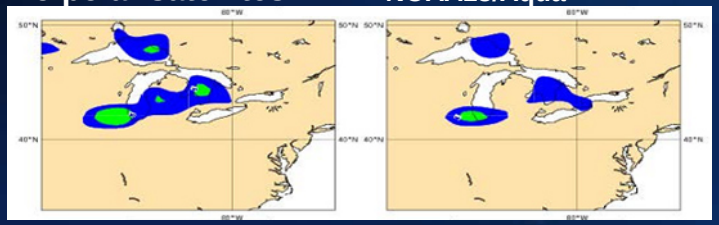
terrain

Why satellite data is important

Snowfall forecast three days in advance of the 19th December 2009 at 12z, from the assimilation system

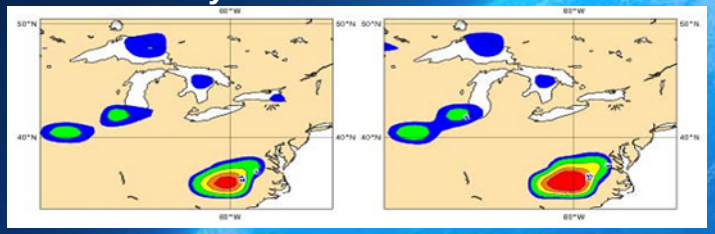
No polar satellites

NOAA18/Aqua



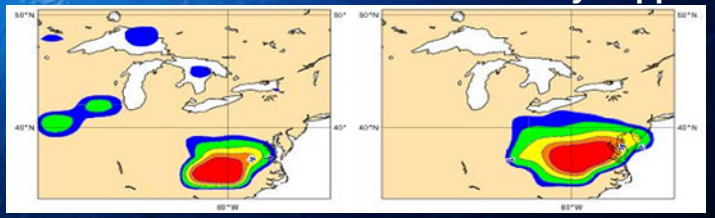
METOP-A only

METOP-A and NOAA18/Aqua



All data

What actually happens



Tony McNally Future degradation of the polar orbiting satellite network - how will it affect Numerical Weather Prediction? , Tony McNally, ECMWF The 18th International TOVS Study Conference (ITSC-18) Toulouse, France

Distribute observed data

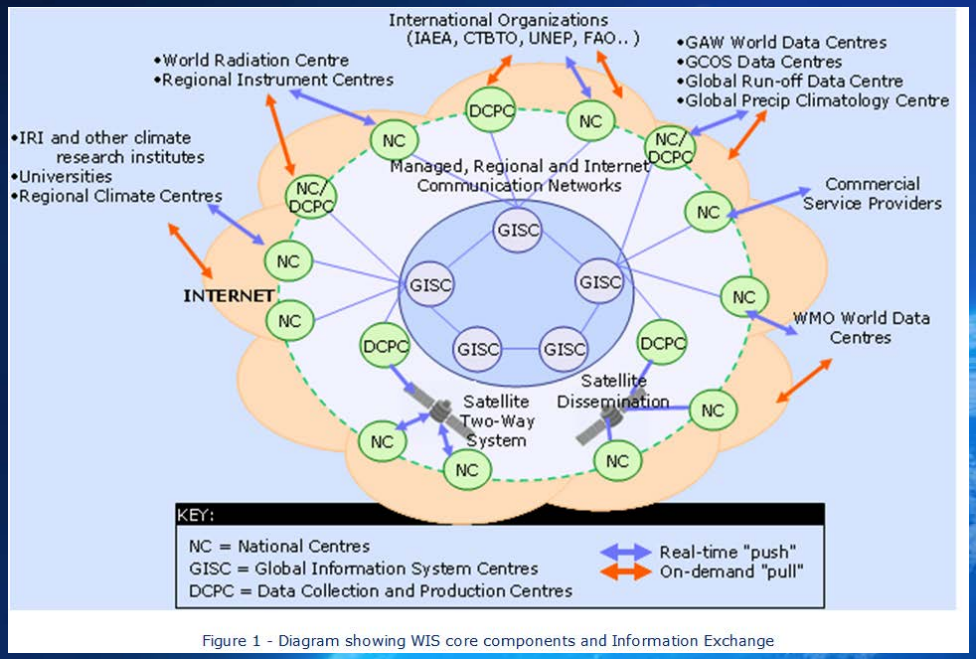
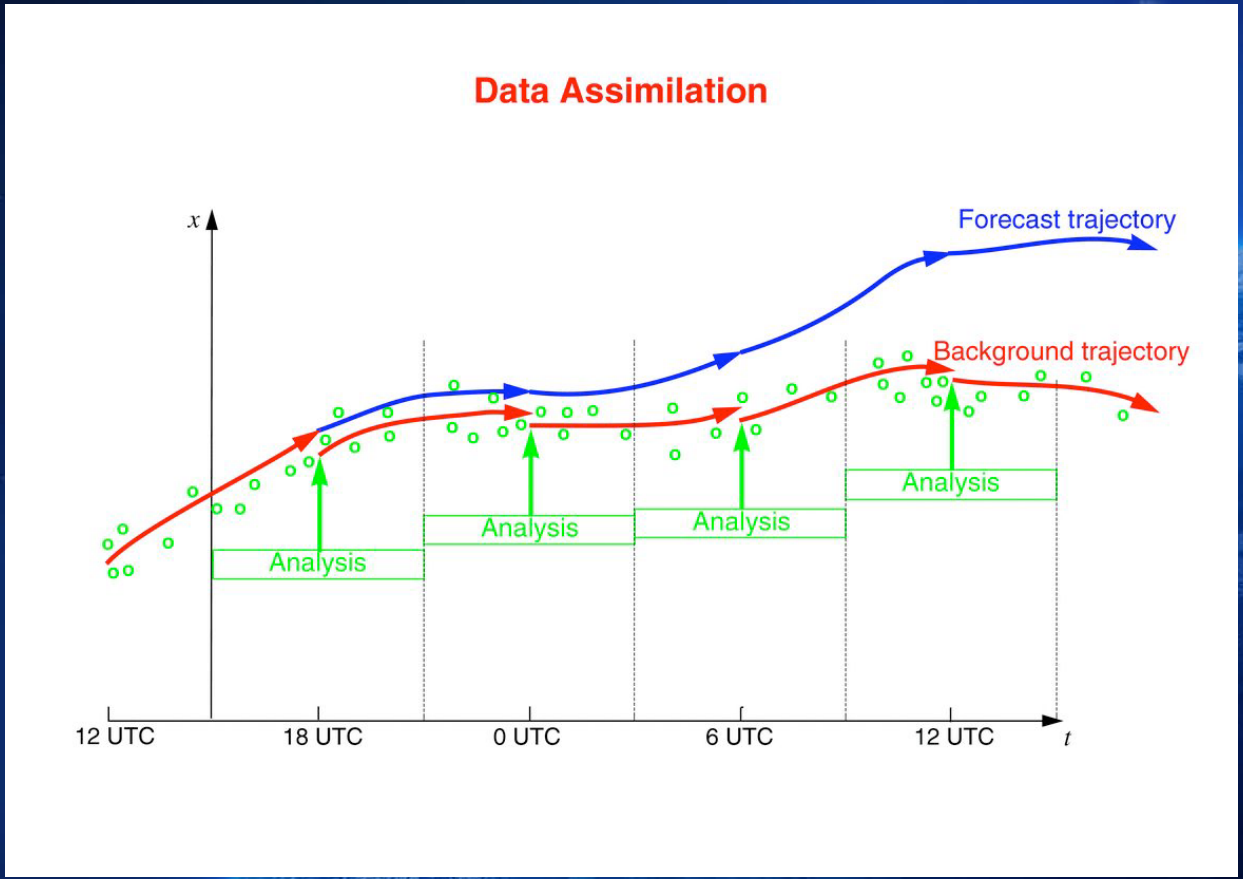


Figure 1 - Diagram showing WIS core components and Information Exchange

- National Centre - numerical weather prediction (NWP) supports single nation/administration
- Data Collection and Production Centre - European Centre for Medium Range Weather Forecasting supports multiple

http://www.wmo.int/pages/prog/www/WIS/centres_en.html

Run weather model



Tony McNally (ECMWF)
http://earth.eo.esa.int/eosummerschool/envschool_2008/lectures/TM_1.pdf

Run weather model

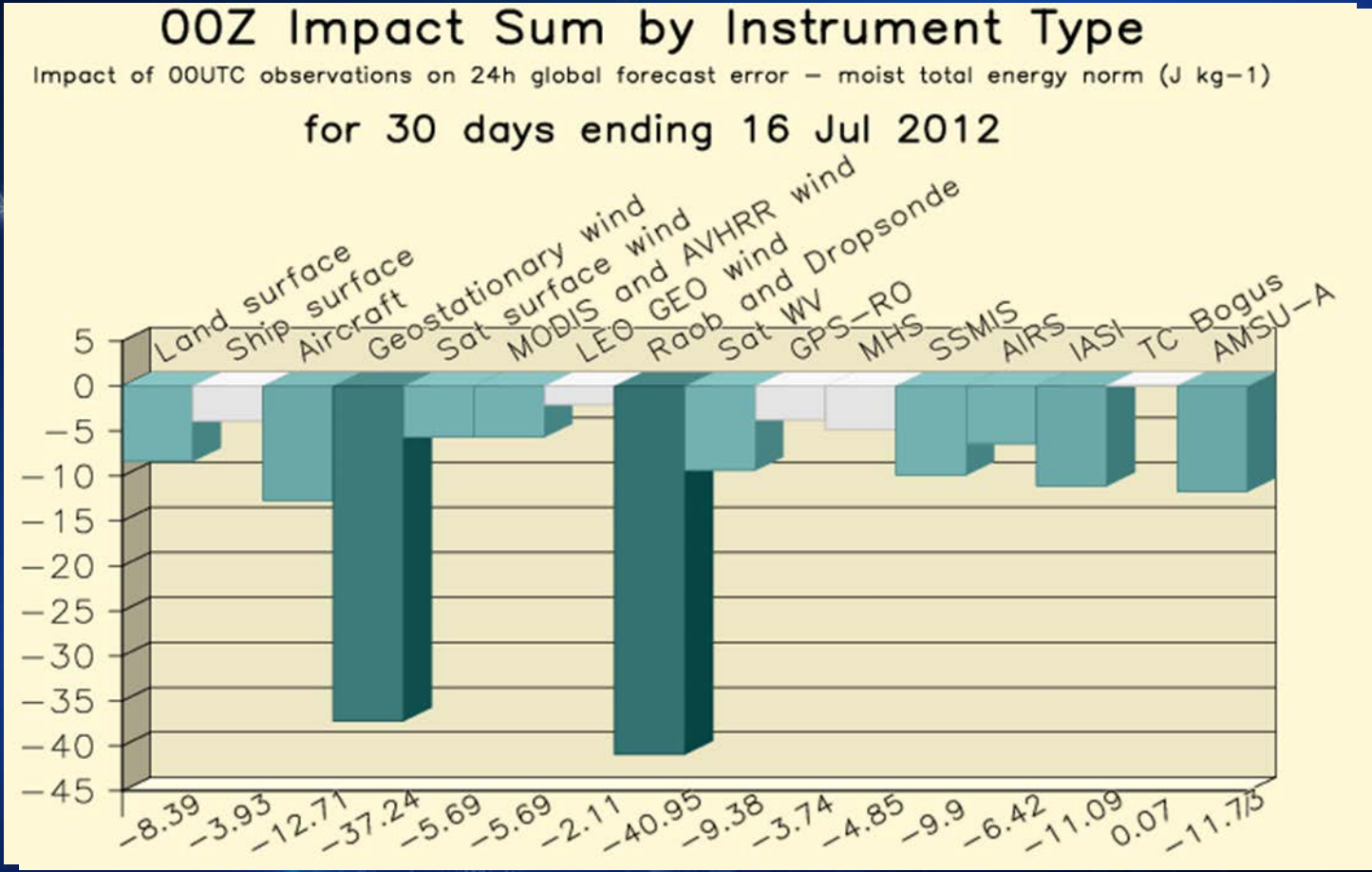
Key elements of numerical weather prediction system[1]

- Start with analysis
- forecast weather variables in small time steps
- Follow laws of thermodynamics and chemistry

This is data assimilation

[1]*After Tony McNally (ECMWF)*
http://earth.eo.esa.int/eosummerschool/envschool_2008/lectures/TM_1.pdf

Weather model output data about weather data



Distribute/disseminate weather information

Based on http://www.wmo.int/pages/prog/amp/pwsp/communicationdissemination_en.htm

- Point to multipoint
- Point to point
- Other methods

The forecast process

https://www.meted.ucar.edu/training_course.php?id=22 (requires free login account)

Add value to weather models

- Value differs from end user to end user
- Users want accurate forecast
  - Some want to know forecaster confidence
  - Some want probabilities
  - Others want "go or no-go" decision

The forecast process

Forecast Process Method

- **The Meteorological Watch (or MetWatch)**
  - Continuous
  - Gain insight into trends
  - Recognize or anticipate departures from the official forecast and model guidance
  - Requires
    - creation of conceptual models
    - personal judgment
    - diagnostic techniques.
- **Diagnose Cause and Effect**
  - Requires forecasters to properly diagnose the cause of forecast departures
  - Meteorologists derive most of the fun from forecasting
  - Identify the cause of this deviation from the forecast –can gain insight into how the forecast will be affected over time.

https://www.meted.ucar.edu/training_course.php?id=22 *(requires free login account)*

The forecast process

- **Determine Plausible Outcomes**
  - Following departure diagnosis
  - Determine appropriate response
  - Decide what could occur due to the discrepancies
  - Assess our degree of confidence based on the analysis/diagnosis and appropriate NWP guidance.
  - Forecast must contain as much detail as confidence allows
  - Not become mired in endless data analysis
  - “Analysis paralysis” prevents from decision making …too much data to analyze
  - Studies have shown that decisions made from limited amounts of data can be superior to ones where more data is pored over (Gladwell 2005).
- **Update**
  - New forecast to reflect forecaster thinking
  - Three components
    - make the forecast reflect current conditions.
    - change the near-term forecast to reflect changes in current conditions.
    - change the longer lead-time forecasts (if warranted) based on
      - conceptual model of atmospheric evolution
      - how it compares to deterministic and probabilistic model forecasts.

Some satellite observing system acronyms

AIRS	Atmospheric Infrared Sounder
AMSU-A	Advanced microwave sounding unit - a
AVHRR	Advanced Very High Resolution Radiometer (AVHRR) sensor AVHRR/3 sensor on NOAA-15, 16, 17, 18 and 19 measures in six bands though only five are transmitted to the ground at any time
Dropsonde	deployed from the aircraft and drift down on a parachute measuring vertical profiles of pressure, temperature, humidity
GEO	geosynchronous satellite 35,786 km (22,236 miles)
GPS-RO	GPS radio occultation
IASI	Infrared Atmospheric Sounding Interferometer
LEO	low earth orbiting satellite (between 160 kilometers (99 mi) and 2,000 kilometers (1,200 mi)
MHS	microwave Microwave Humidity Sounder
MODIS	Moderate Resolution Imaging Spectroradiometer - a scanning spectro-radiometer with 36 spectral bands between 0.645 and 14.235 μm
Raob	rawinsonde observation
Sat WV	satellite water vapour
SSMIS	special sensor microwave imager/sounder
TC Bogus	tropical cyclone bogusing