The unique capabilities of the Global Hawk aircraft for the study of climate changes

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Global Hawk – New Capability for High Altitude, Long Endurance Earth Science

NASA has acquired two Global Hawk aircraft for Earth Science missions

Configuration

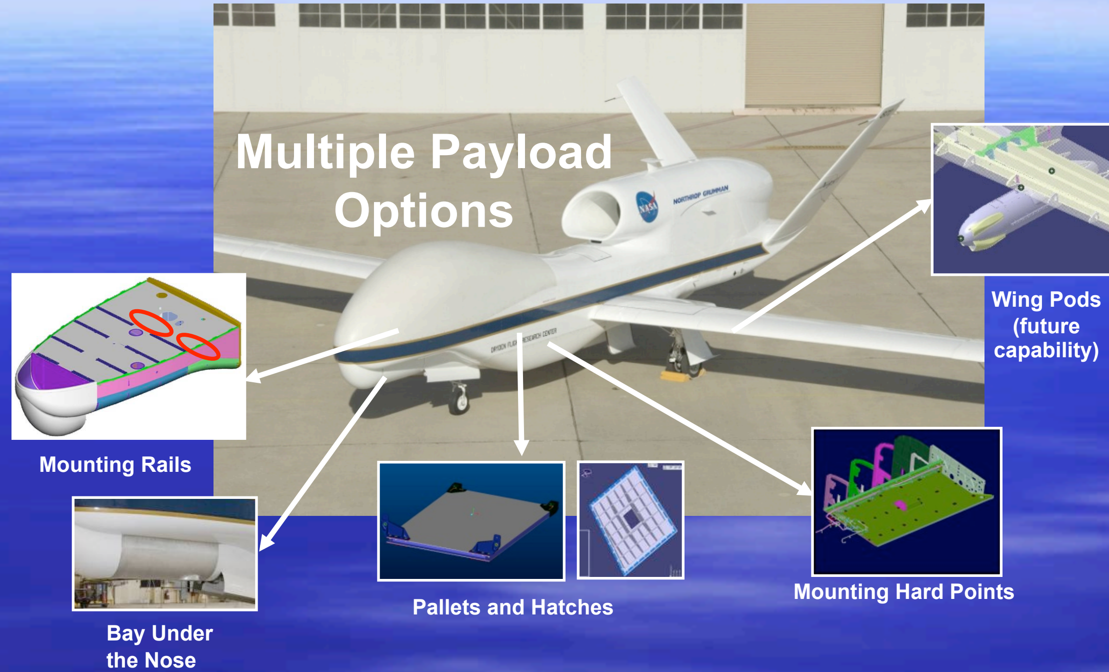
- Wingspan: 116 ft
- Length: 44 ft
- Unmanned vehicle
- Highly reliable, fully autonomous control

Performance

- Endurance > 30 hours
- Range > 20,000 km
- Altitude > 19 km

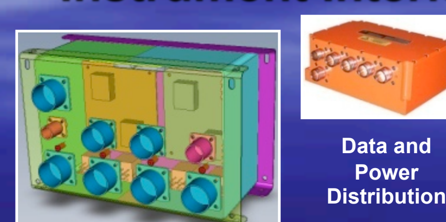
Global Hawk – Mission Support Features

- Payload ~ 680 kg
- Experiment power
  - 2.0 KW DC
  - 8.8 KVA AC
- In-flight command and control of instruments



Global Hawk Operations Center

Standardized Instrument Interface



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LEO satellites:

global coverage few minutes of observational time on target, twice per day

vertical (> 1-2 km) horizontal (10 km) resolution

GEO satellites:

coverage over a vast regions (1/6th of Earth) continuous coverage,

vertical (>5 km) horizontal (1 km) resolution

development ~5-10 years

Global Hawk (GH):

synoptic coverage, few hours of observational time on target,

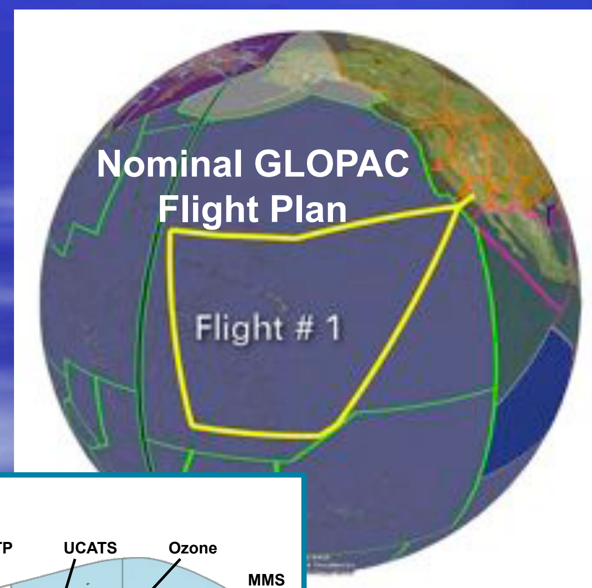
vertical (> 0.01km) horizontal (> 0.1 km) resolution

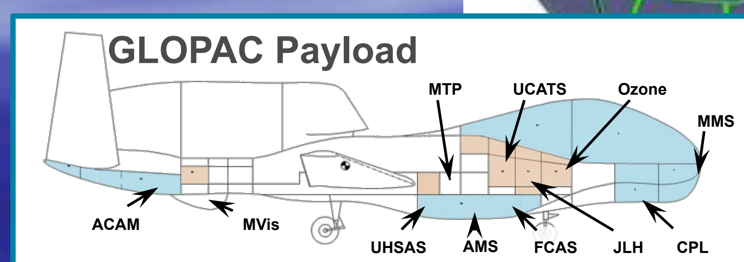
development ~5-10 months

GH has the great potential to fill gaps between space-borne and surface based observations and to provide a fast demonstration for future sensors

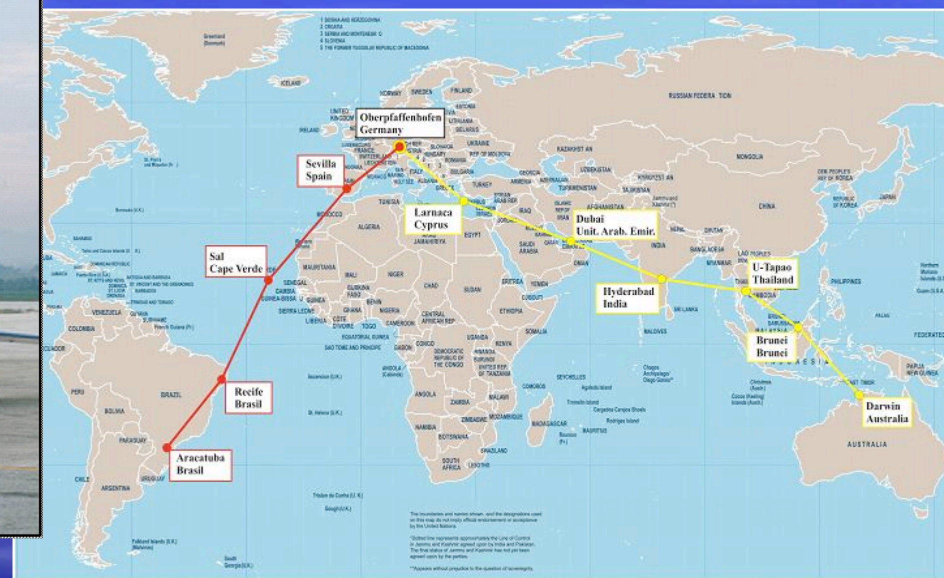
Global Hawk – Present Status

- Preparations for first NASA flights nearly complete
- First science mission:
  Global Hawk Pacific (GLOPAC)
  - July, 2009
  - 12 instruments; NASA,NOAA sponsored
  - Flight over Pacific and Arctic Oceans
- Second science mission:
  Genesis and Rapid Intensification Processes (GRIP)
  - Summer, 2010





Italian research with high altitude research MDB M-55 Geophysica aircraft initially motivated by ozone depletion at the poles, then extended worldwide to Troposphere – Stratosphere interactions



The Italian scientific community has expressed a strong interest in the use of the GH for Climate Change studies.

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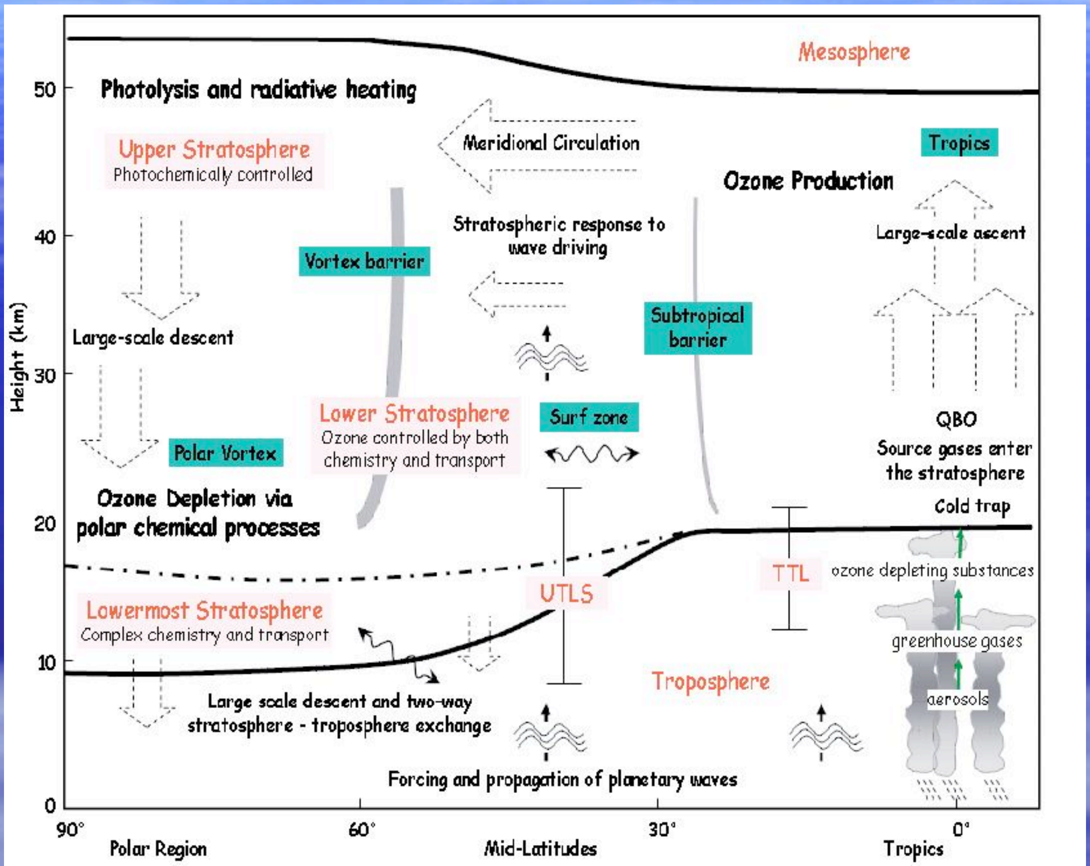
Outstanding research fields in climate change studies have been considered :

- Upper Troposphere – Lower Stratosphere processes
- Earth Radiation Budget
- Greenhouse gases
- Air Quality
- Ecosystems and Climate
- Water Cycle

Upper Troposphere – Lower Stratosphere processes



Eyring et al., 2005

Critical UTLS processes can be addressed with high resolution in situ measurements of key species, dynamical and radiative variables, accessible via long endurance stratospheric aircraft.

- Permeability of subtropical and polar mixing barriers
- Strength of the Brewer –Dobson circulation
- Stratosphere-Troposphere Exchange
- Solar UV-visible photolysis
- Photochemistry and Chemical processes
- Polar processes
- Aerosol and Cirrus

Earth Radiation Budget (ERB)

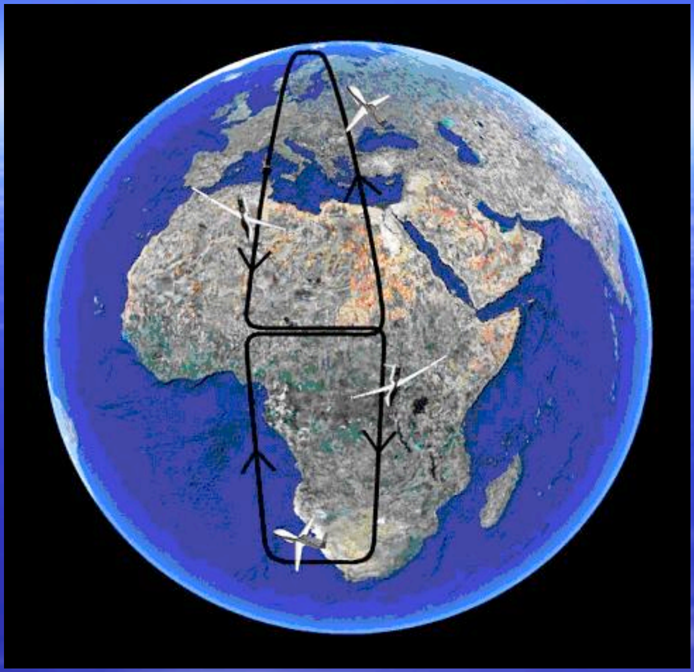
Radiative measurements of the short wave (SW) and long wave (LW) outgoing radiation flux for the identification of the causes of ERB changes

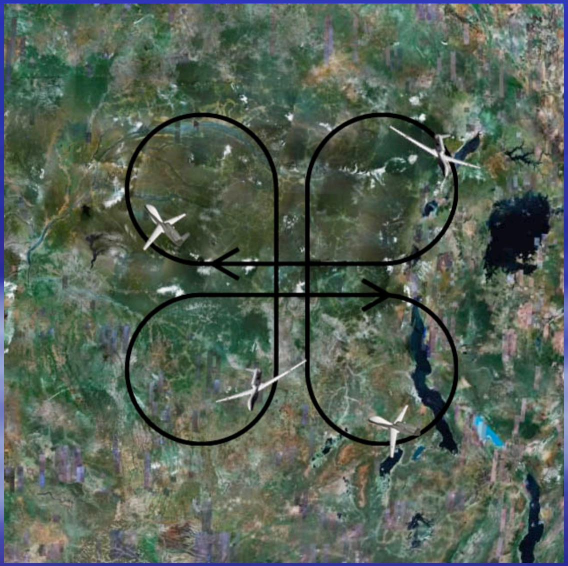
- Measurements of the surface albedo of the Earth with its two-dimensional scattering properties
- Measurements of aerosols and clouds with their contribution to both the greenhouse effect and the albedo at the top of the atmosphere
- Measurements of the atmospheric composition and of its greenhouse effect

The GH can

- Operate at an altitude close to the boundary conditions of radiative processes
- deploy new ERB instruments without the long development time and high cost of new space-borne instruments
- acquire measurements coincident with those of the existing satellite ERB measuring instruments

The GH observations can have coverage as good as that of satellite ones in terms of seasonal and geographic monitoring and better than those in terms of combined angular and time observations.





The GH with its long endurance is the only platform from which it is possible to observe the same pixels at different angles during a full day for determining its two dimensional albedo as a function of the solar zenith angle.

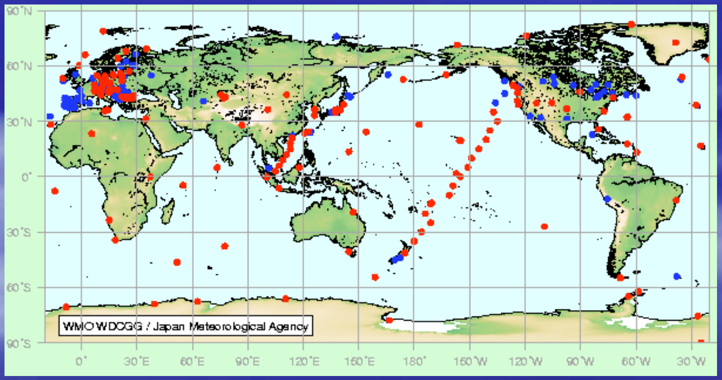
Greenhouse gasses (GHG)

To predict future trends in the global carbon cycle it is essential :

- To determine sources and sinks of GHG and in particular of CO_2.
- To improve the measurements of water vapour profile and understand its feedbacks.

The GH allows more precise observations, with integration times much longer than satellite measurements, due to the relatively slow movement of the aircraft and to the possibility of performing several overpasses

Accounts for the possibility of linking the observation from aircraft with the locations of both existing GHG ground stations and satellite observations



In the case of operation from Europe, this capability would be further enhanced by the high density of European ground stations

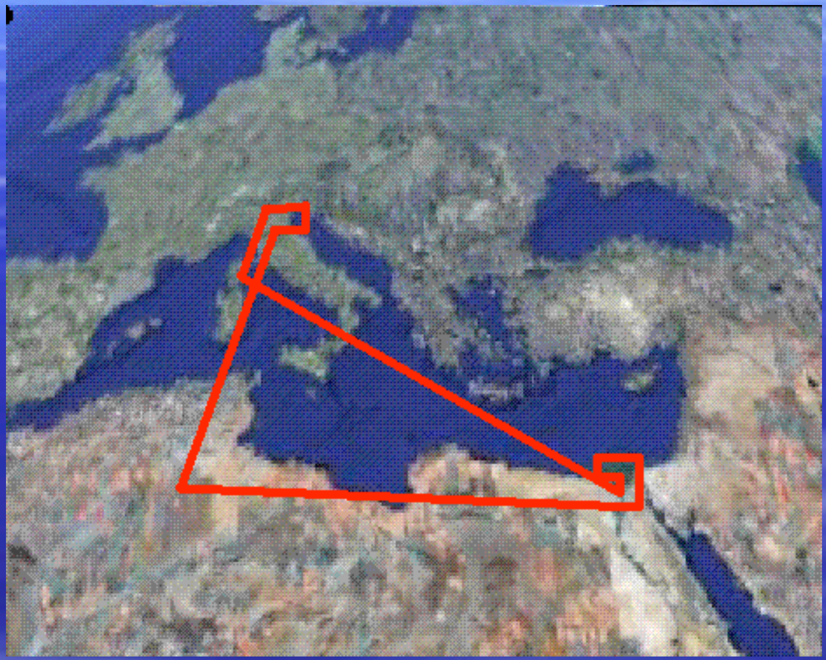
Air Quality

Air quality and climate are strongly interlinked:

Pollutants change atmospheric composition and severely affect air quality at the local and regional scale, but also affect climate: aerosols change the Earth's radiation balance and the atmospheric lifetime of greenhouse gases (GHG) impacts ecosystems and agriculture productivity

key measurements are: Aerosol profile, O_3 concentration profile, column density of NO_2 and HCHO

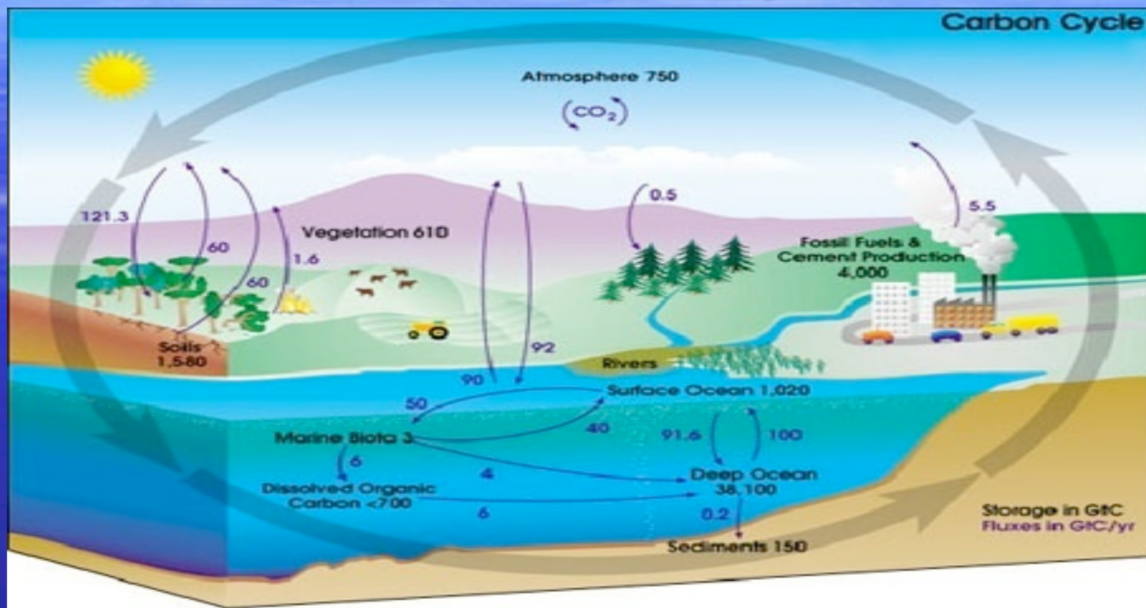
With GH it is possible to make continuous diurnal measurements in areas with different levels of pollution



deploy new instruments that operate day and night and/or can measure new species to characterize the air self-cleaning capability

Ecosystems and Climate

The link between ecosystem changes and climate change, while important, is poorly understood.



Key issues are :

ecosystem photosynthetic rate monitoring and its relationship with climate change;

soil behaviour and soil behaviour modification monitoring;

monitoring of ecosystems carbon storage.

Possible GH objectives are :

The validation of satellite hyperspectral measurements with high resolution measurements that are not feasible from space.

Flight demonstration of photosynthesis efficiency measurements made with new techniques (either Laser Induced Fluorescence or Fraunhofer Line discrimination principle)

Courtesy of ASI

Water Cycle

Precipitation is the key physical process that links weather, hydrological cycle and climate.

Key issues are:

Assess the ability of different types of particles to act as CCN and IN as a function of their size, origin and air mass history

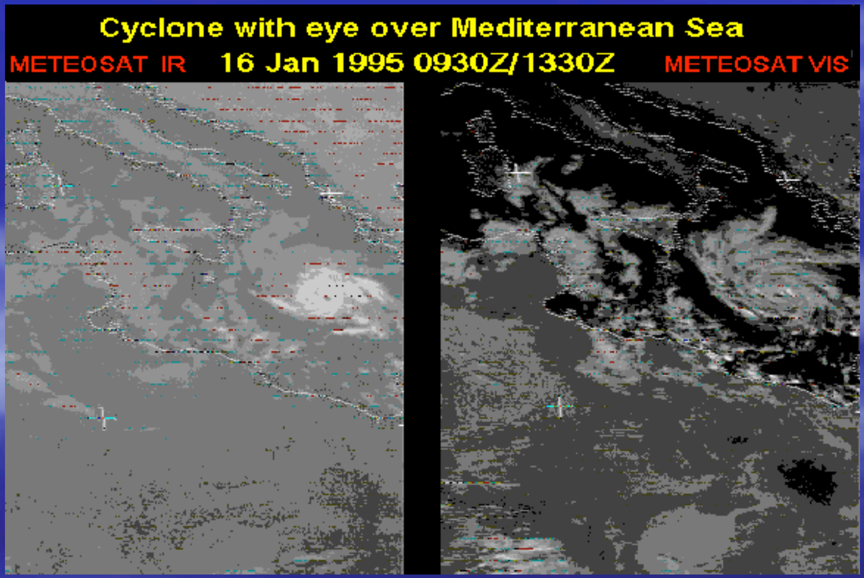
Assess the influence of anthropogenic aerosol on cloud microstructure in different areas

To study the nature and development of hazardous storms

To quantify the role of snowfall in the water cycle at high latitudes

Radars, microwave radiometers, lidars, are primary tool to address these issue from a high-flying platform.

They can be hosted on a flock of GH, their long endurance allowing the study of cloud systems following their evolution over very large areas.



Meteosat-5 image

The availability of such powerful new platform - of unprecedented capabilities in terms of endurance, flight altitude useful payload - will help unraveling key scientific issues for climate change science

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