Trajectory Prediction & Control: *Weather Prediction*

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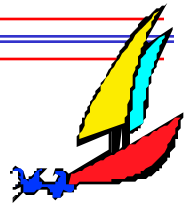
Trajectory Control: *Weather Prediction*

What is needed

- Methods to control latitude
- Altitude control systems for superpressure balloons
- Windsails
- Propulsion systems
- New Balloon designs

Today's State of the Art

- Wind prediction good for about 3 days in upper stratosphere

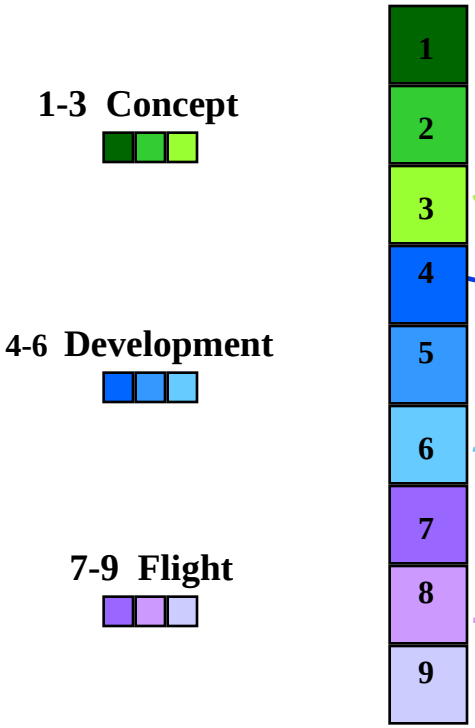


Technology Goals

- Improve the assimilation of stratospheric observations
- Extend useful range of weather prediction
- Use forecast winds to predict trajectories

Trajectory Control: *Weather Prediction*

Technology Required *"Needed By"*



- Stratospheric weather forecasting
  - 30-40 km
  - 20-50 km
  - 2002
  - 2008
- 1 to 2 week wind predictions
  - 2000
- 2 to 3 day wind vector predictions
  - 2003
- Wind vector knowledge
  - 2000

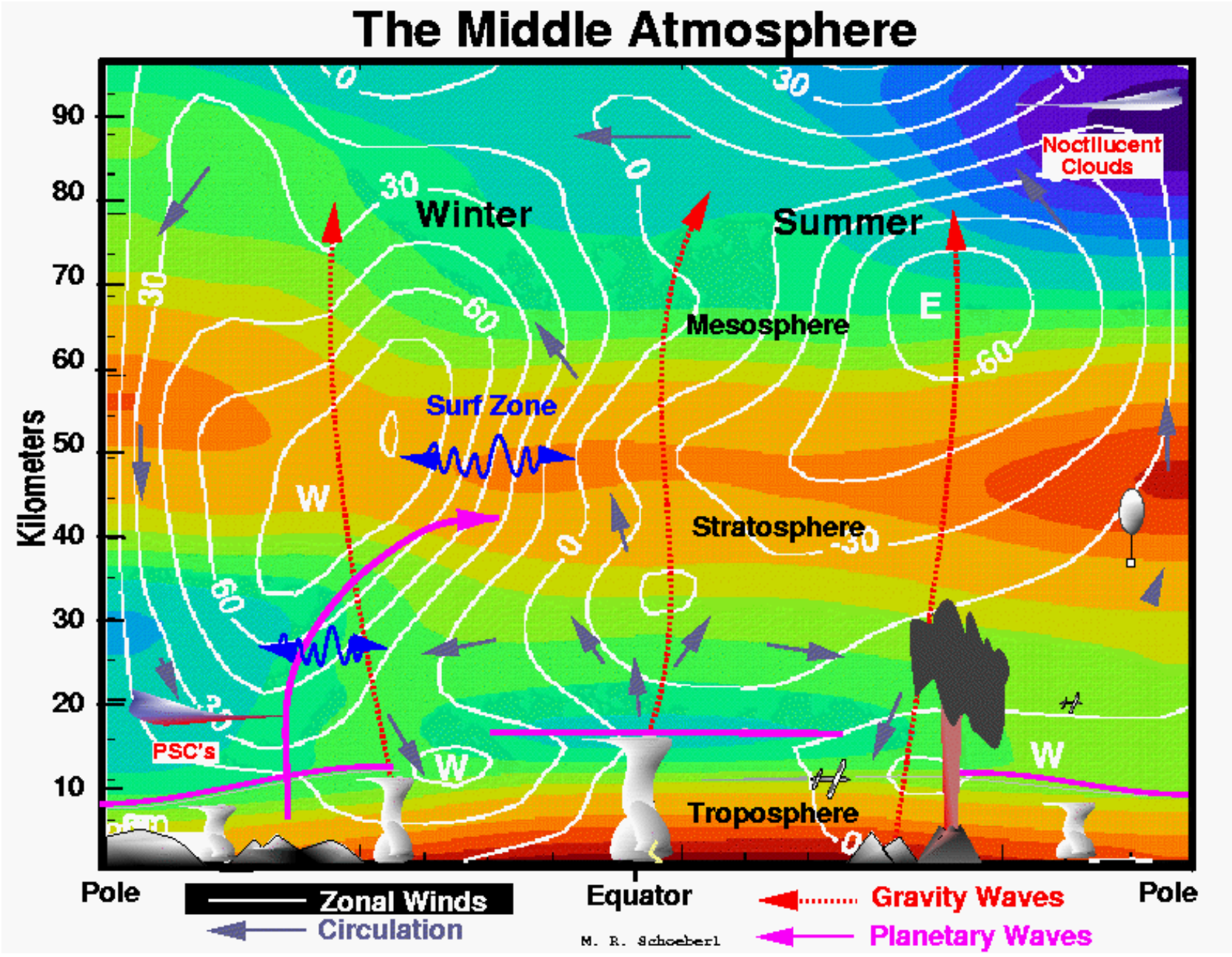
Current Technology Readiness Levels

Stratospheric Weather Prediction

- Introduction to Stratospheric Weather Prediction
- What the DAO can contribute to the ULDB Project
- Future Prospects

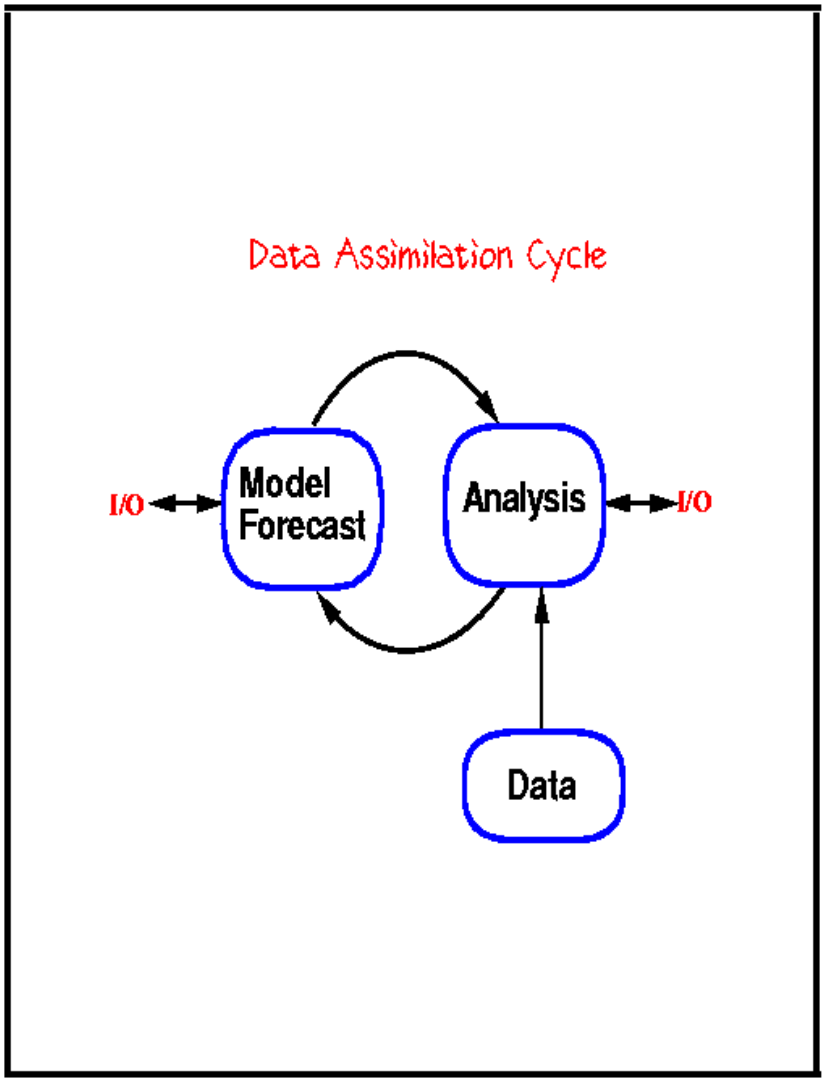
Introduction to Stratospheric Weather Prediction

- The Stratosphere
  - Extends from about 15 km to about 50 km altitude
- Overview of stratospheric circulation:
  - Weak easterlies in summer, gradually evolving to…
  - Strong westerlies in winter
  - Strong wave activity in winter, culminating in "stratospheric warmings", particularly in the Northern Hemisphere
- Observations available:
  - Many different types of observations in the troposphere
  - Radiosonde measurements of wind, temperature up to ~20-30 km, Satellite temperature soundings up to ~50 km
  - No operational wind measurements above ~30 km


The Middle Atmosphere
Kilometers
90
80
70
60
50
40
30
20
10
Winter
Summer
Noctilucent Clouds
Mesosphere
Surf Zone
Stratosphere
Troposphere
PSC's
E
W
W
W
W
0
30
60
-30
-60
Pole
Equator
Pole
Zonal Winds
Circulation
Gravity Waves
Planetary Waves
M. R. Schoeberl

Introduction to Stratospheric Weather Prediction

- Forecasting Model
  - Produces weather prediction by numerical solution of equations representing processes in the atmosphere
    - Current configuration has 70 levels
    - Extends from surface to 0.01 hPa (~80 km altitude)
    - Horizontal resolution 2 deg latitude x 2.5 deg longitude
- Data Assimilation System
  - Produces initial data for the forecast model
    - Uses a statistical algorithm (known as PSAS, Physical-space Statistical Analysis System) to combine informationfrom observations with “background data” from forecast model
    - Forecast model organizes and summarizes information from previous observations.

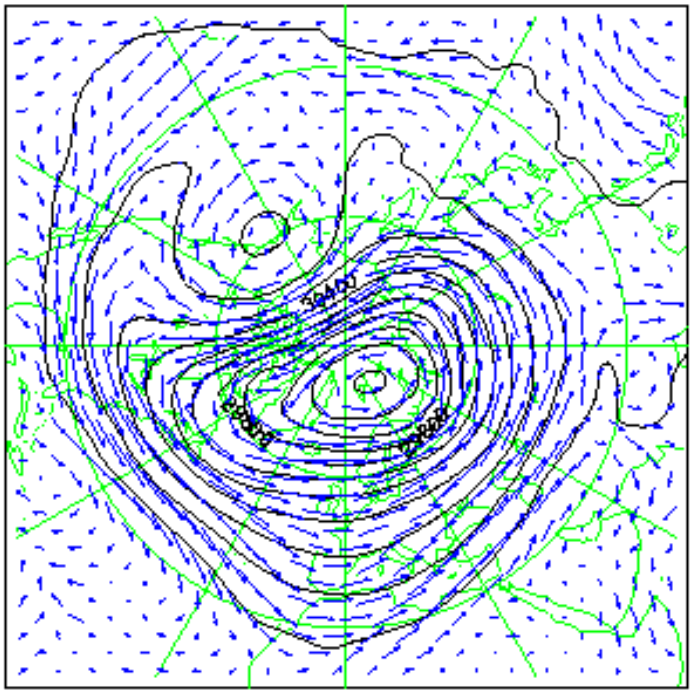

Data Assimilation Cycle
I/O
Model
Forecast
Analysis
I/O
Data

7

What the DAO can provide for the ULDB Project

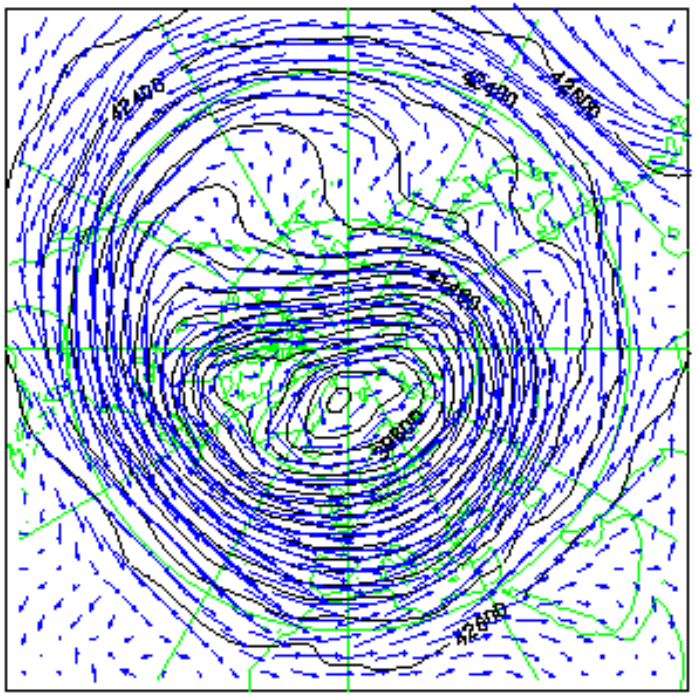
- Heritage of DAO support for previous stratospheric aircraft measurement campaigns
- Analysis of observations in near real time
- Running forecasts for prediction of balloon trajectories
- Provision of wind data and information on radiative fluxes

Height and wind at 10 hPa (~30 km)
08 Nov 92 DAO Assimilation



→ represents 20 m/s

Height and wind at 2 hPa (~40 km)
08 Nov 92 DAO Assimilation



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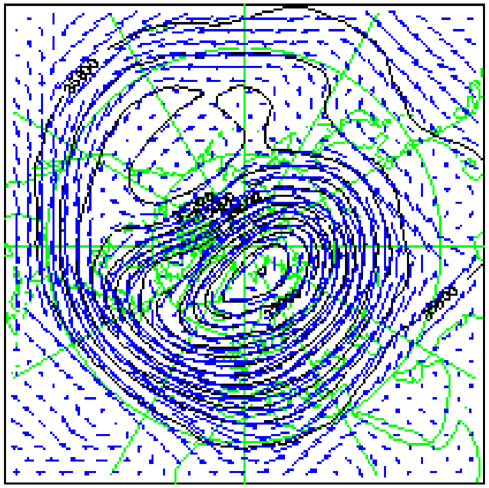
Stratospheric Forecasts

- Test forecasts have been run and estimates made of forecast accuracy
  - Wind errors have been assessed by comparing with later analyses
  - But, since there are no *in situ* wind observations, the actual wind vectors are not known
  - Local wind errors are not necessarily a good indicator for trajectory forecasts, since they will depend on integrated errors along the trajectories
  - Skill of forecasts will be seasonally dependent

Height and wind at 5 hPa (~35 km)
09 Nov 92 DAO Assimilation



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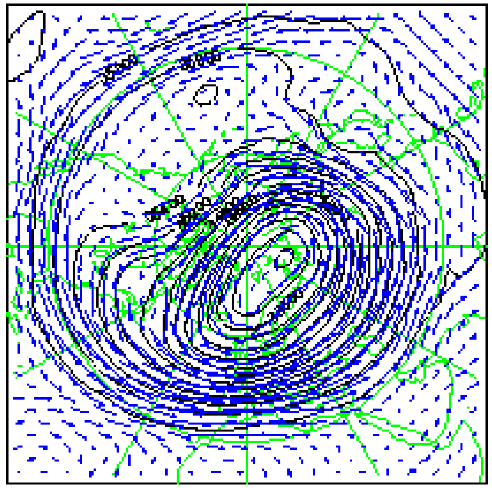

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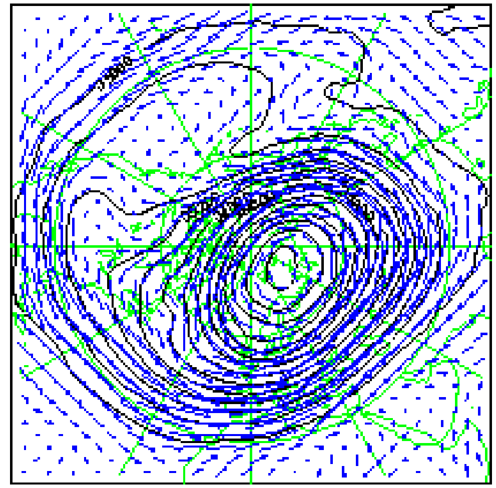

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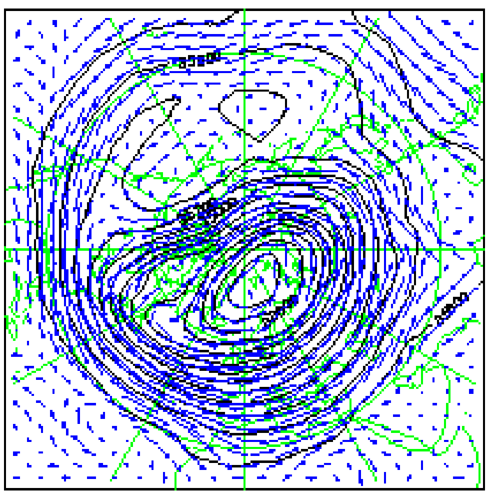
Height and wind at 5 hPa (~35 km)
09 Nov 92 DAO Forecast



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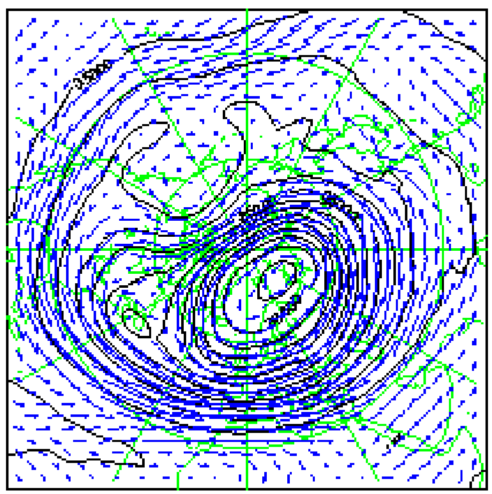

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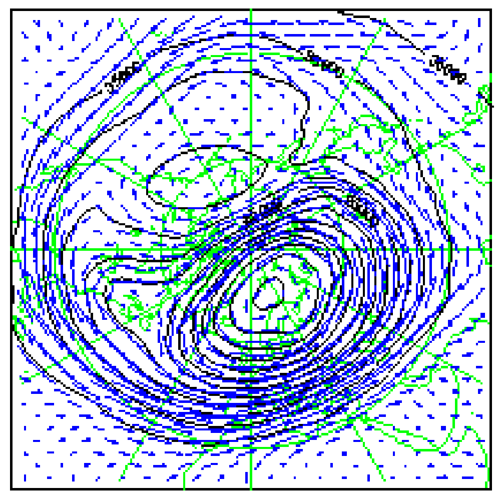

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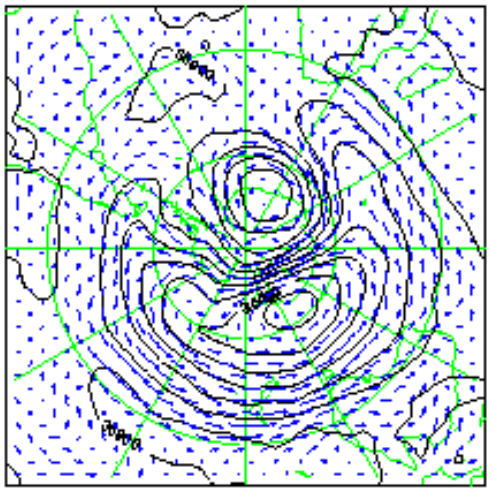

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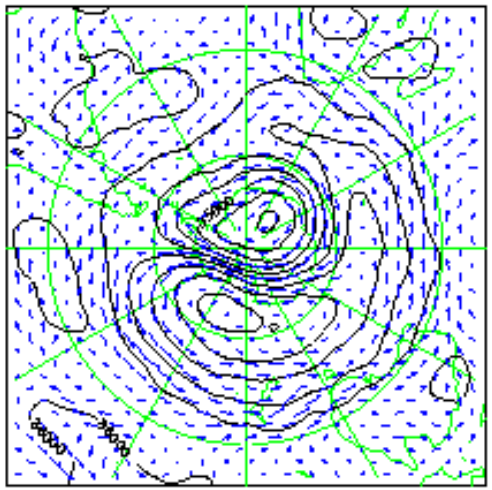

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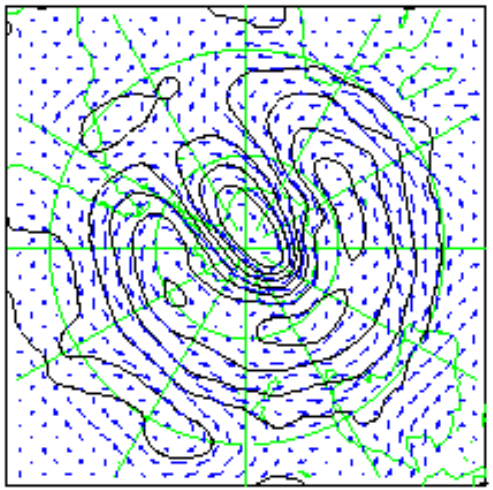

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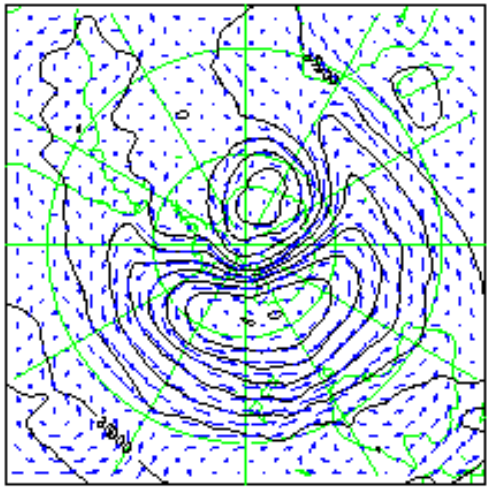

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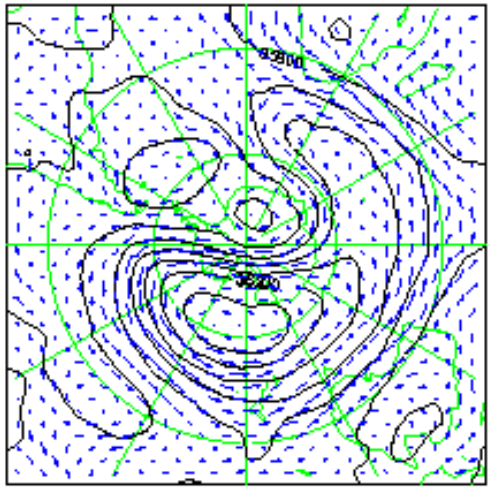

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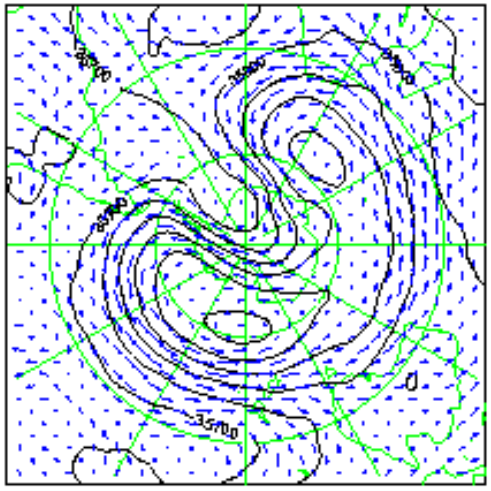
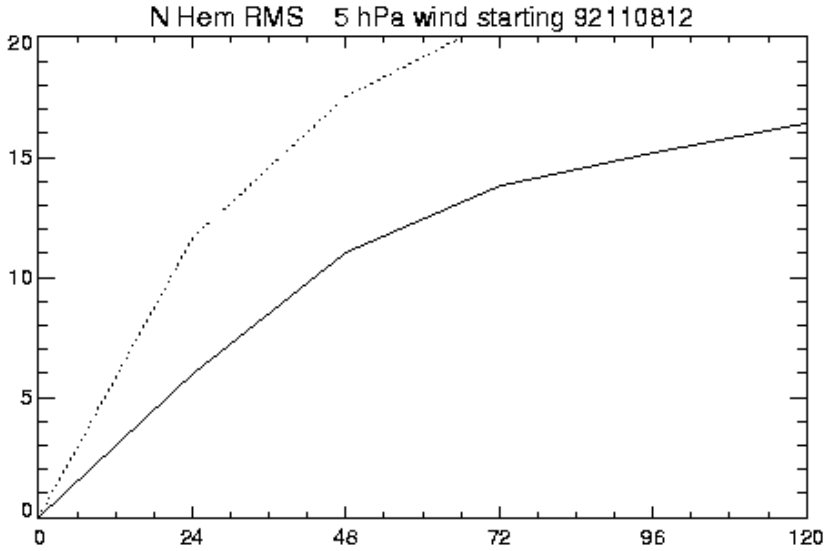
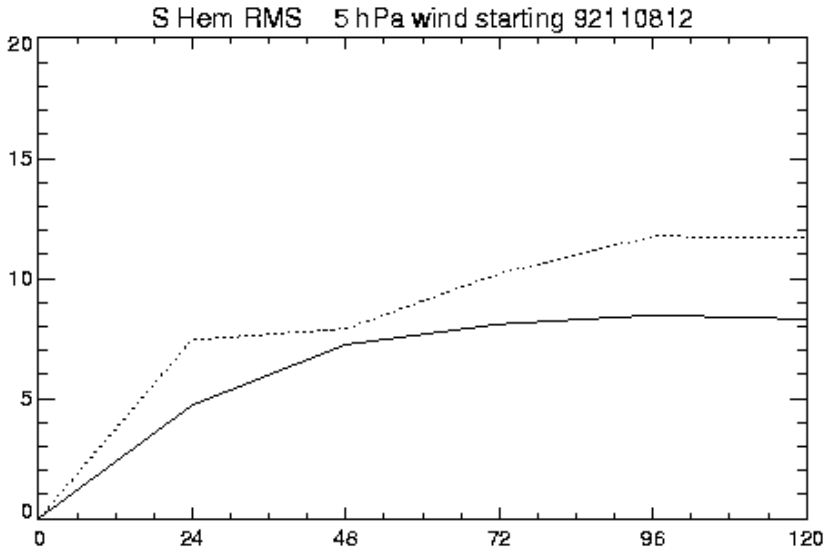



N Hem RMS 5 hPa wind starting 92110812
20
15
10
5
0
0
24
48
72
96
120


S Hem RMS 5 hPa wind starting 92110812
20
15
10
5
0
0
24
48
72
96
120

Future Prospects

- Changes to Data Assimilation System (next 2-3 years)
  - Improved horizontal resolution (1 degree), with model top at 0.1 hPa (~65 km)
  - New model, with improved dynamical core
  - Better use of satellite temperature soundings, using an interactive retrieval system.
- Possible new data (longer term)
  - Direct wind measurements from satellites
  - In situ wind measurements from high altitude balloons

Summary

- Stratospheric Weather Prediction
  - Prediction of stratospheric winds is possible for a period of several days
- What thte DAO can contribute
  - Near real-time provision of analysis and forecast wind data
- Future Prospects
  - Improvements to the quality of analyses and skill of forecasts