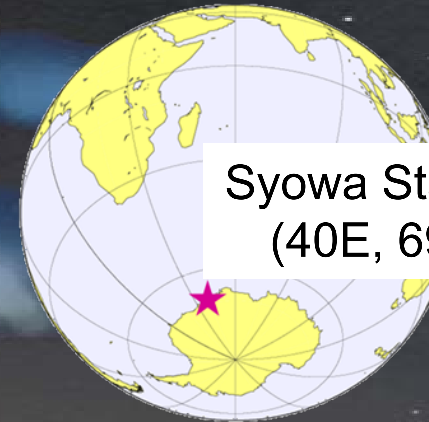
PANSY

Program of the Antarctic Syowa MST/IS Radar

PANSY



Syowa Station
(40E, 69S)

Construction started in the end of December, 2010

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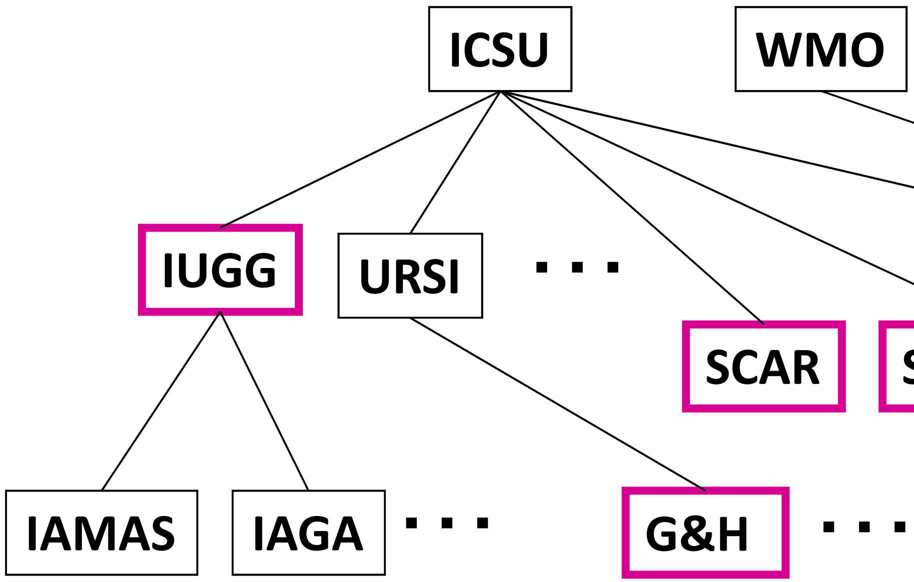
SCHOOL OF SCIENCE
THE UNIVERSITY OF TOKYO

NiPR
National Institute of Polar Research

PANSY is derived from the French word, 'pensee', meaning 'thought'

International Resolutions and Recommendations on MST/IS Radar in the Antarctic

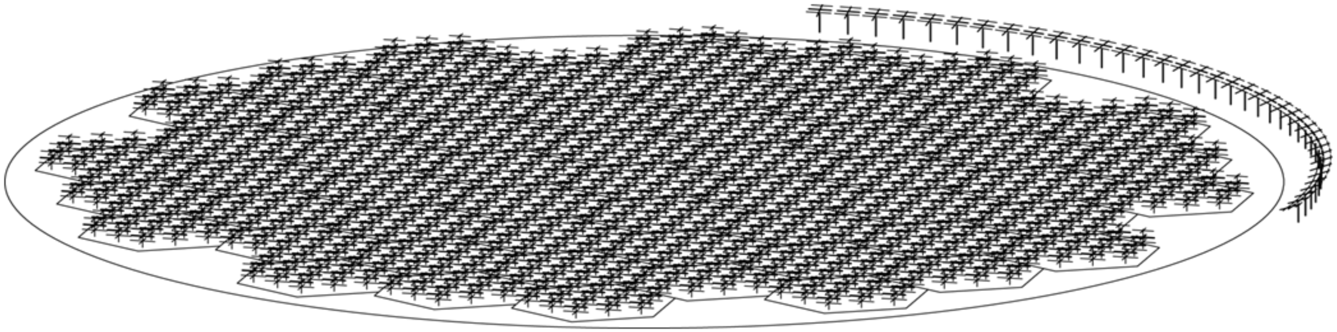


Thank you very much for your strong and continuous support to our project!

Specifications of PANSY

- Height coverage : 1-500km
- Three dimensional winds and plasma parameters
- Fine time and height resolutions

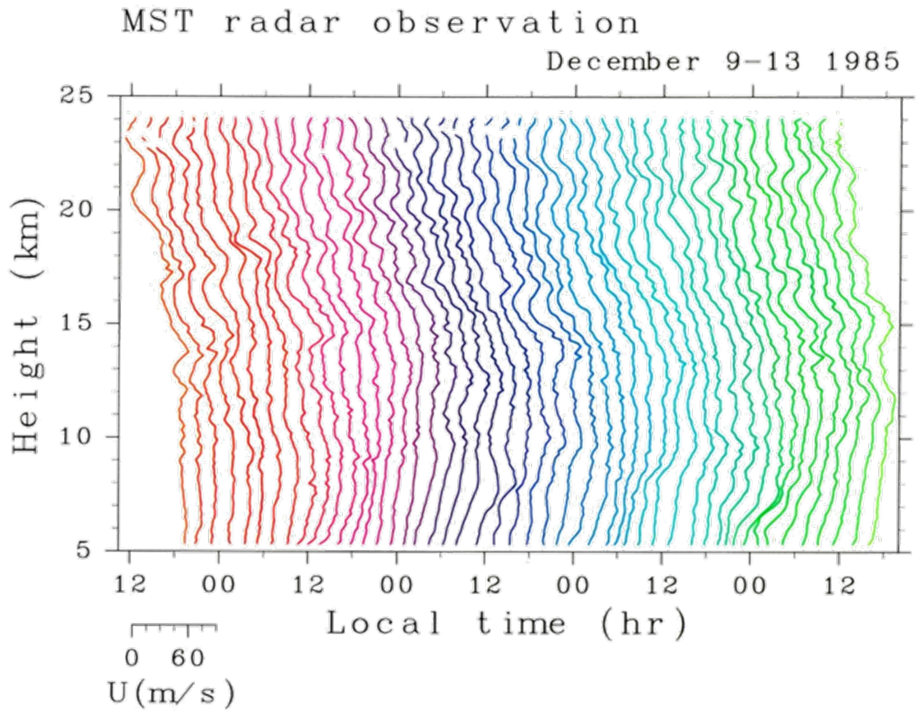
System	Pulse Doppler radar. Active phased array system
Center freq.	47MHz
Antenna	A quasi-circular array consisting of 1045 crossed Yagi antennas. Diameter about 160m ($18000m^2$)
Transmitter	1045 solid-state TR modules Peak Power : 520kW
Receiver	55 channel digital receiving systems Ability of imaging and interferometry obs
Peripheral	24 antennas for E-layer FAI observation



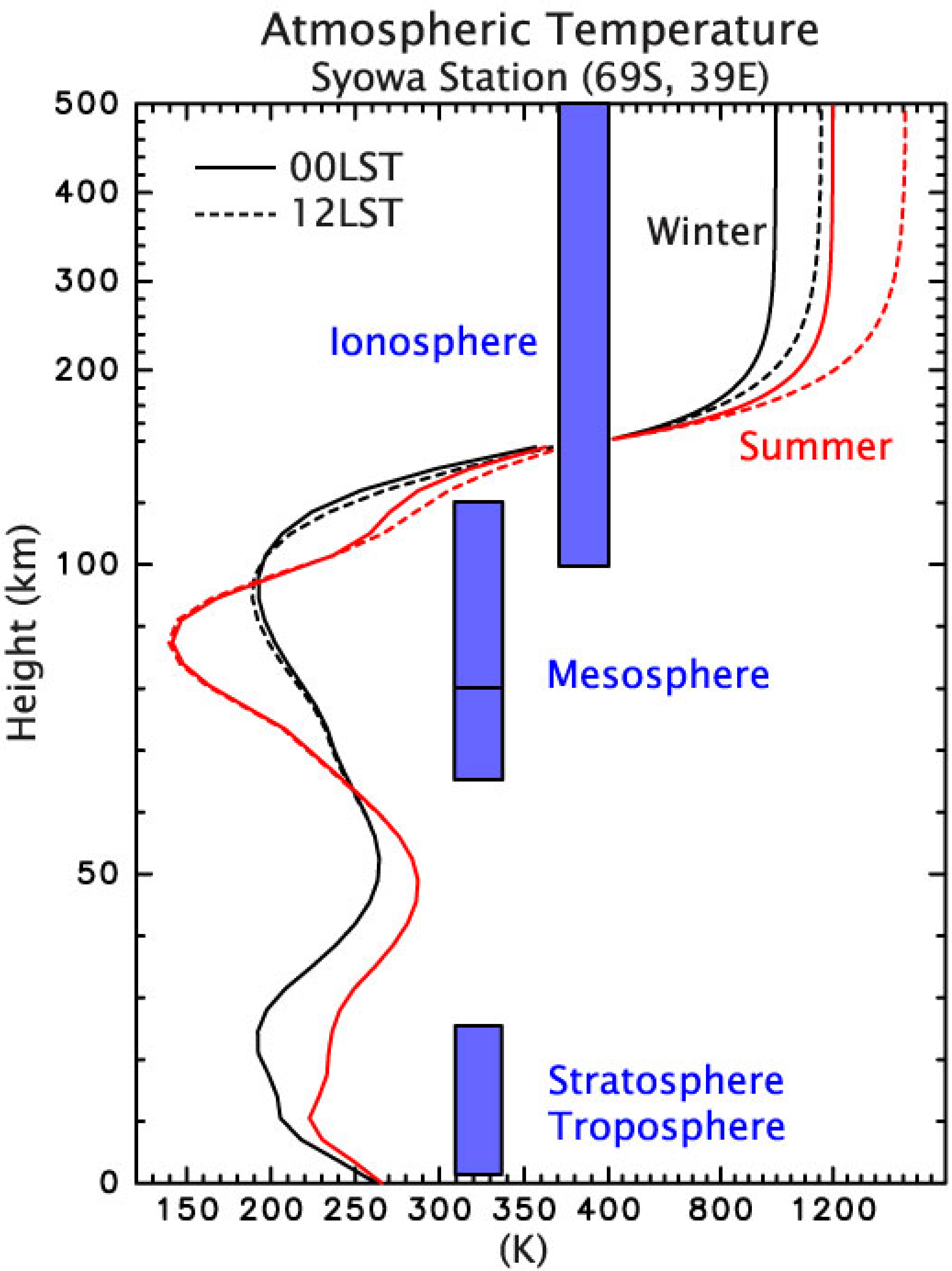
Performance of the PANSY radar
MST observation

Turbulence echo

- 3-d winds in the troposphere and stratosphere
  - ⊿t=1min, ⊿z=75-150m
- 3-d winds in the mesosphere
  - ⊿t=1min, ⊿z=300-600m
- PMSE(Polar Mesosphere Summer Echo) observation
- Much better than 3-d winds in the mesosphere



The MU radar
(35N, 136E)


Atmospheric Temperature
Syowa Station (69S, 39E)
00LST
12LST
Winter
Summer
Ionosphere
Mesosphere
Stratosphere
Troposphere
Height (km)
500
400
300
200
100
50
0
150
200
250
300
350
400
800
1200
(K)


Aurora


PMC


PSC

Science of PANSY

- Katabatic winds: The role on the circulation in the Southern Hemisphere
- Boundary layer: Turbulence structure, Exchange with free atmosphere
- Circulation in the troposphere: Meridional circulation, Water circulation
- Polar lows: 3-dimensional structure and dynamics
- Severe snow storms: Generation mechanisms and 3-dimensional structure
- Blockings: Exchange with the middle atmosphere, wave generation
- Tropospheric-stratospheric exchange: Tropopause structure, turbulence, dominant disturbances, ageostophic circulation
- Ozone hole: Dynamics and chemistry of ozone layer recovery
- Polar stratospheric clouds: Physics of generation and dissipation. Their radiative, chemical, and dynamical roles
- Trapped waves on the polar vortex: Roles on the exchange between the regions inside and outside of the polar vortex
- Polar night jet: Small-scale structures and secondary circulation
- Sudden warming: Dynamics. Transport and mixing
- Gravity waves: Dynamical characteristics, generation mechanism, vertical and seasonal variation, momentum fluxes, wave forces, horizontal propagation
- Exchange between the mesosphere and thermosphere: Mesopause structure, dominant disturbances, ageostrophic circulation
- Polar mesospheric clouds (Noctilucent clouds): Monitoring of climate effects by human activity, physics of generation and dissipation, roles on radiation
- Barotropic and baroclinic instability: Interaction with gravity waves
- Polar mesospheric summer echoes/polar mesospheric winter echoes: Mechanisms and relation with the polar mesospheric clouds.
- Auroras: 3-dimensional structure
- Ionospheric disturbances: Comparison between the Arctic and Antarctic atmospheres
- Coherent scattering in the ionosphere: Mechanism, structure, time variation
- Irregularity in the ionospheric E region: Structure, seasonal variation etc.
- Solar proton events: Effects on the neutral atmosphere
- Diurnal, seasonal, inter-annual variations, solar cycle (11 years), and trends: Mechanism and effects by GHGs.
- Turbulence: 4 dimensional imaging observation

Polar mesospheric clouds (Noctilucent clouds)
appear in the coldest region around 90km in polar summer mesosphere
It is considered that they did not exist at least before the Industrial Revolution → “the canaries in a coal mine” of the Earth climate system

PMSE（Polar Mesosphere Summer Echo）and PMCs

M. Rapp and F. J. Lübken: Review of PMSE

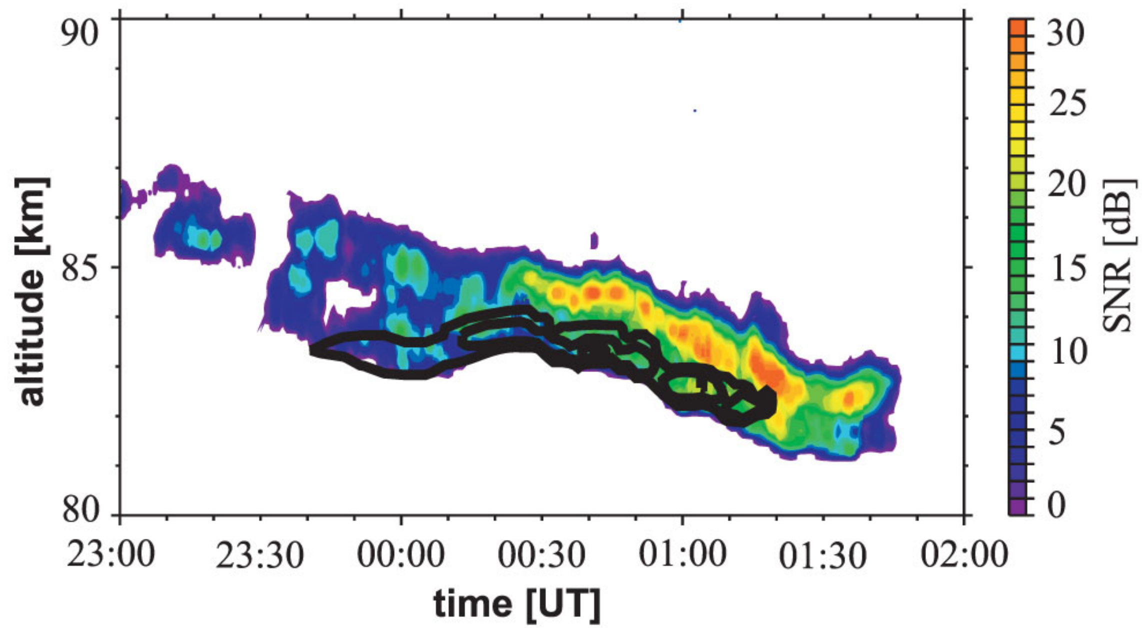
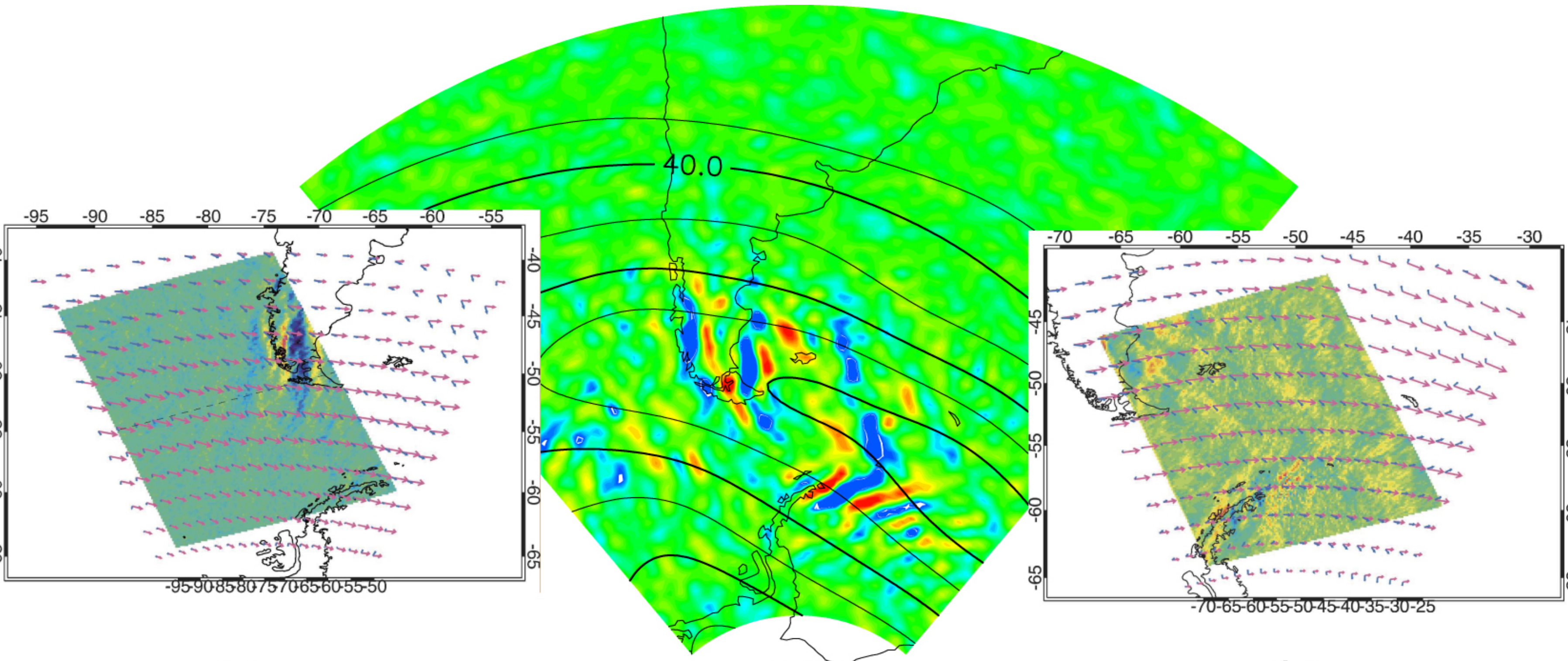


Fig. 15. Radar signal to noise ratio (SNR, colored contours) detected with the ALOMAR SOUSY radar as a function of altitude and time. The black isolines mark the noctilucent cloud detected by the ALOMAR RMR lidar. This figure is reproduced from

The PANSY radar has sufficient power to detect turbulence echoes irrespective of the existence of PMCs.
Research on cloud physics using air motion data around PMC is possible.

Gravity wave simulation with a high-resolution general circulation model (KANTO project)

K. Sato, S. Watanabe, Y. Kawatani, Y. Tomikawa, K. Miyazaki, and M. Takahashi

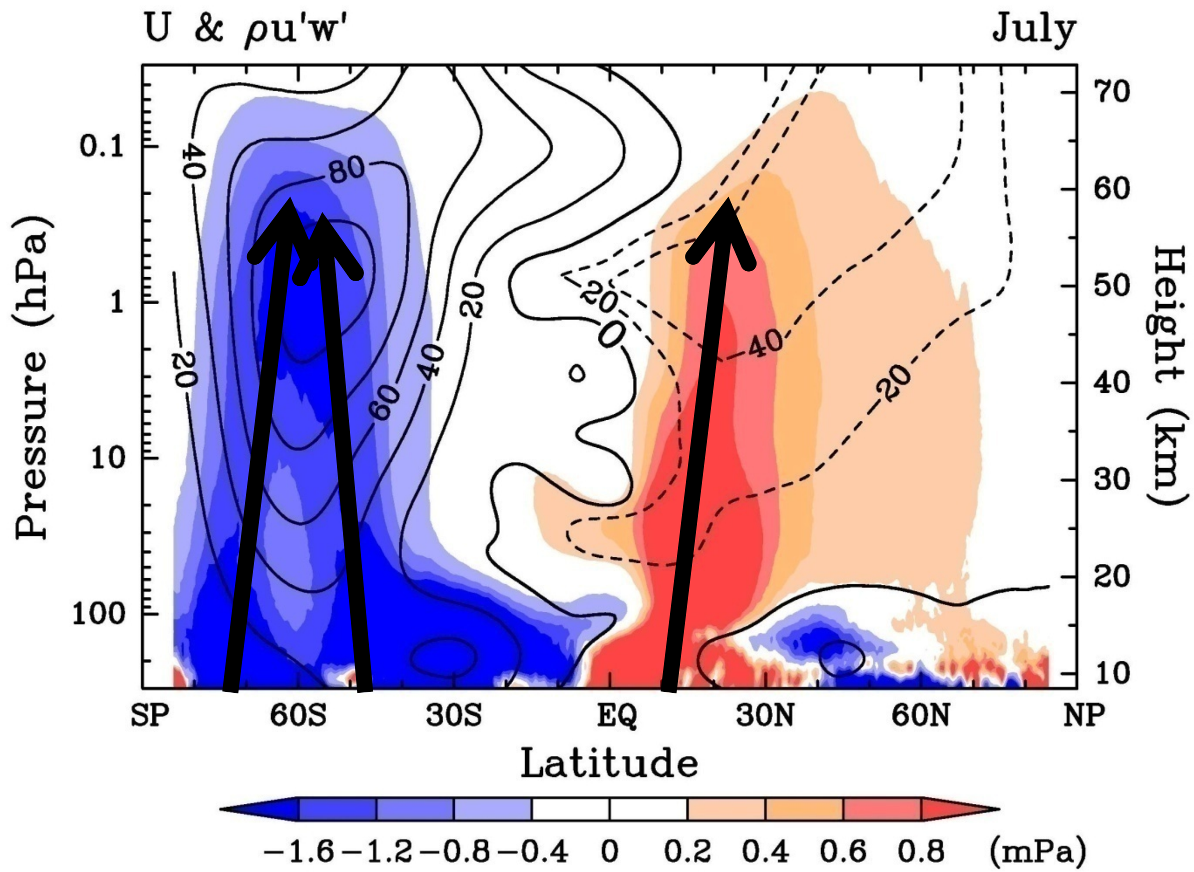


(a) (c) (b)

(a) (b) AIRS (Alexander and Barnet, 2007)

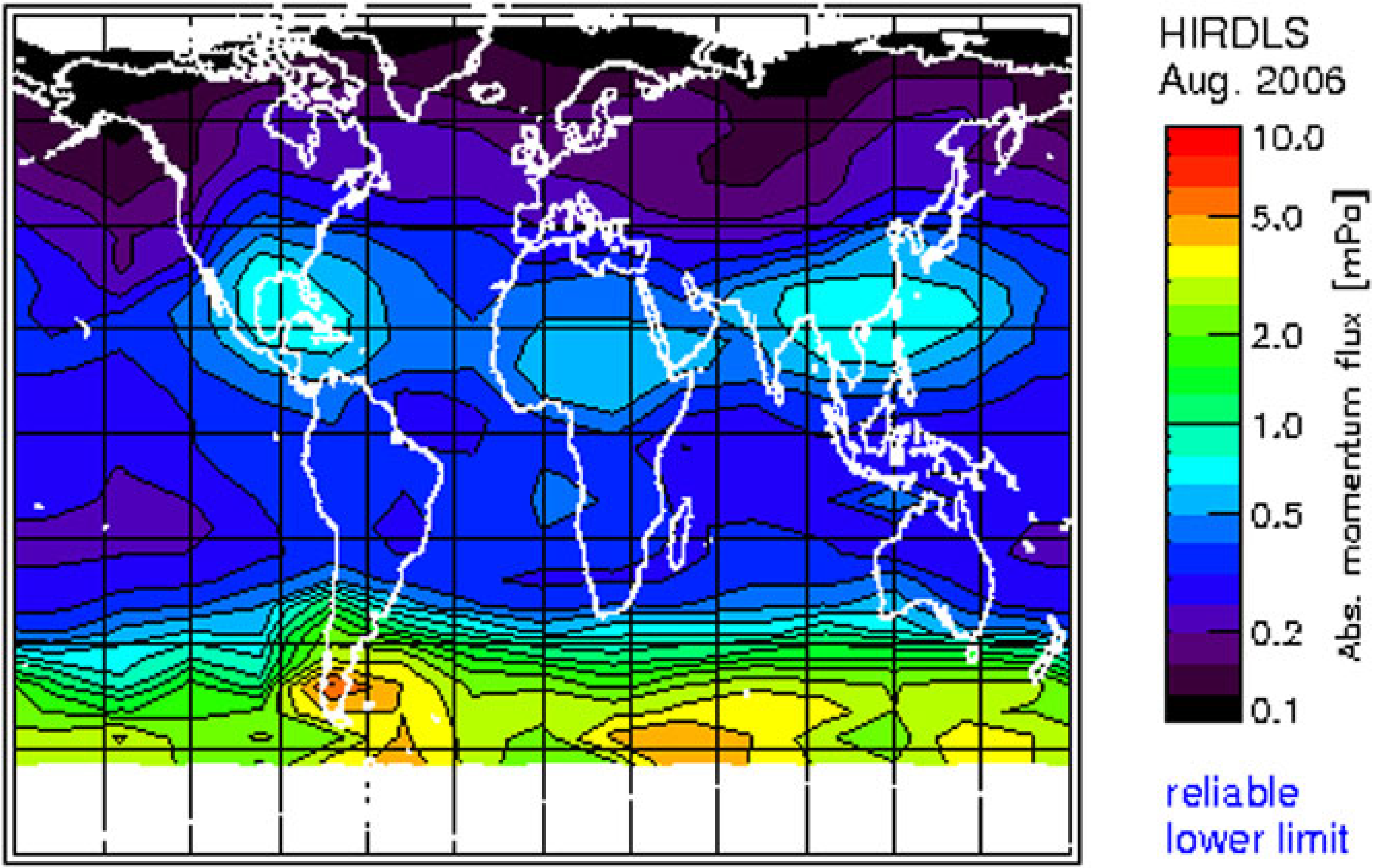
(c) KANTO model (T213L256, Watanabe et al 2008)

Vertical momentum fluxes associated with gravity waves (n>21)



Gravity waves tend to take propagation paths toward the jet axes
→decelerate the jets effectively (Sato et al., 2009)

Recent satellite observations with high resolution



Alexander et al. (2008)

- Satellites provides the lower limit of absolute values of momentum fluxes.
- The PANSY radar provides accurate estimates of momentum flux vectors.

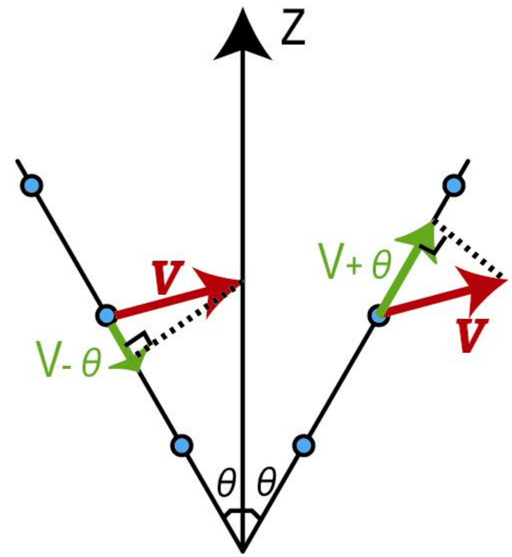
Estimation of momentum fluxes by an MST radars
(Vincent and Reid, 1983)

Using radial velocities of symmetric beams

Wind fluctuations V' (u', w')

$$V'_{+\theta} = u'_{+\theta}\ \sin\theta\ + w'_{+\theta}\ \cos\theta$$

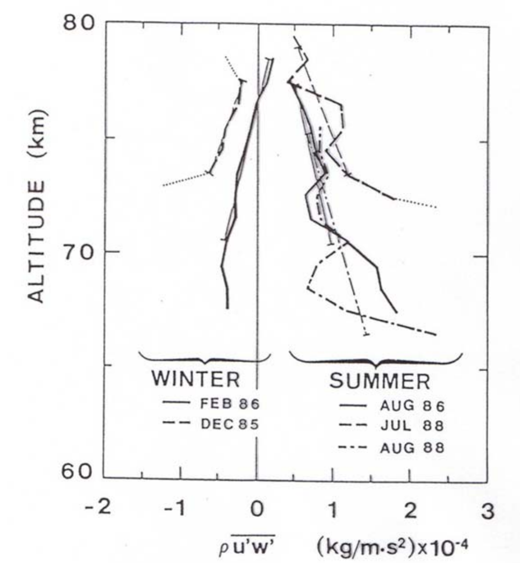
$$V'_{-\theta} = -u'_{-\theta}\ \sin\theta\ + w'_{-\theta}\ \cos\theta$$



Assuming homogeniety of wind variances

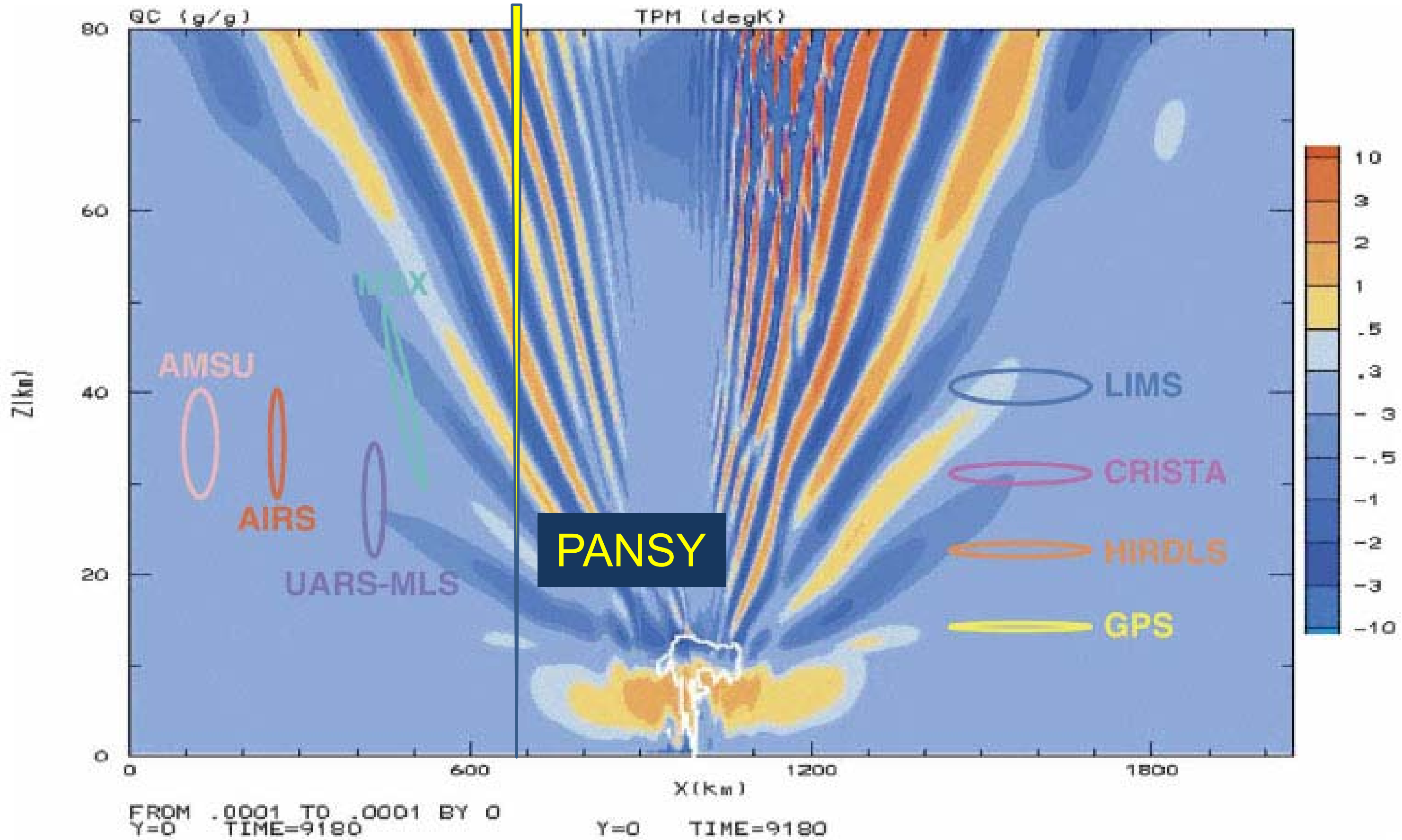
$$(\overline{u'^2_{-\theta}} = \overline{u'^2_{+\theta}},\quad \overline{w'^2_{-\theta}} = \overline{w'^2_{+\theta}})$$

$$\overline{u'w'} = (\overline{V'^2_{+\theta}} - \overline{V'^2_{-\theta}})/2\sin 2\theta$$



The MU radar observation
(Tsuda et al., 1990)

Horizontal and vertical resolution of satellite observations

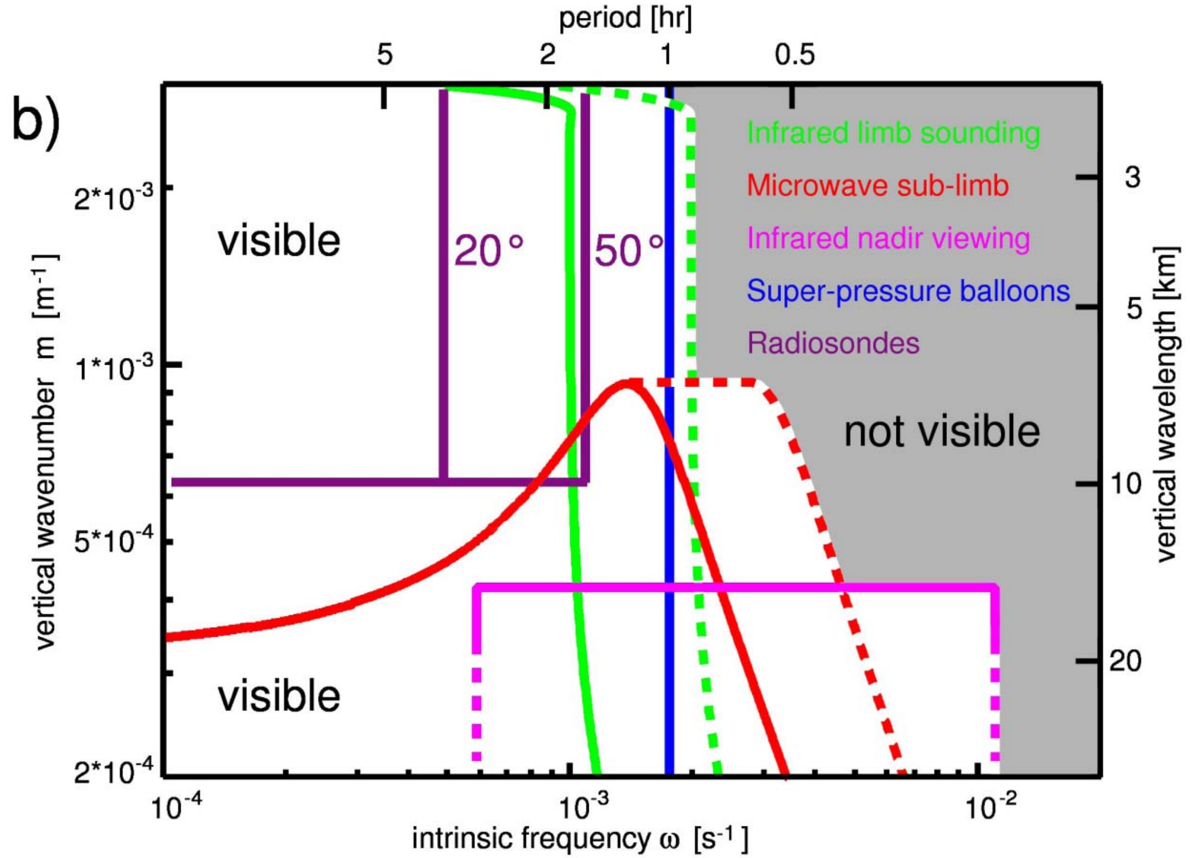


Alexander & Barnet (JAS, 2007)

Horizontal resolution corresponding to the beam width is ～3 km in the upper mesosphere.

The highest vertical resolution of the PANSY radar is 75m

Observational filter problem



Alexander et al. (QJRMS, 2010)

The MST radars (Δt=1min) can observe a part of the spectral range that satellites and balloons cannot observe

The MU Radar (Kyoto University)

（Shigaraki, Shiga, Japan）

Feasibility Study

- Start of the PANSY project 2000

- Field Survey (2002~)

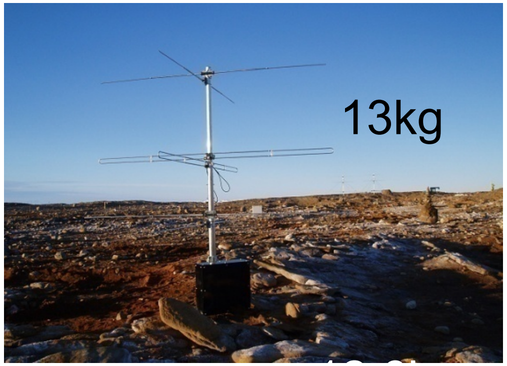
- Development of power efficient class-E transmitters (2003~)

  Twice as power-efficient as conventional class-AB transmitters.

  Estimated total power consumption ~75kW

- Optimization of Yagi antennas (2003~)

  Light-weight. Easy to set up and robust



Position on JARE plan

- Proposal was accepted as a principal observation in the VIII JARE observation plan (6 yrs starting at JARE52 (FY2010))

- Funded by the economic stimulus package by Japanese government in FY2009

Construction and observation time schedule of the PANSY radar

FY	2009	2010	2011	2012
Training system "Sumire" at the MU observatory with 22 antennas	manufacture Start operation	Feedback as needed		
Radar system at Syowa Station in the Antarctic	manufacture	Start observation with a limited system	Start observation with a full system	

- FY2010: Startup of basic observation (e.g. turbulence echo observation) with 3 groups
- FY2011: Startup of multi-receiver system

Training system “Sumire” (2% model) at the MU radar observatory in Shigaraki, Japan

Sumire is used to confirm the radar system performance
and for training the operator at Syowa Station

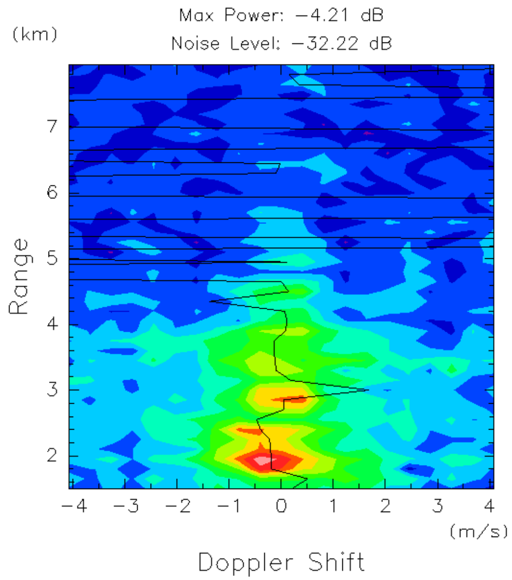
Configuration

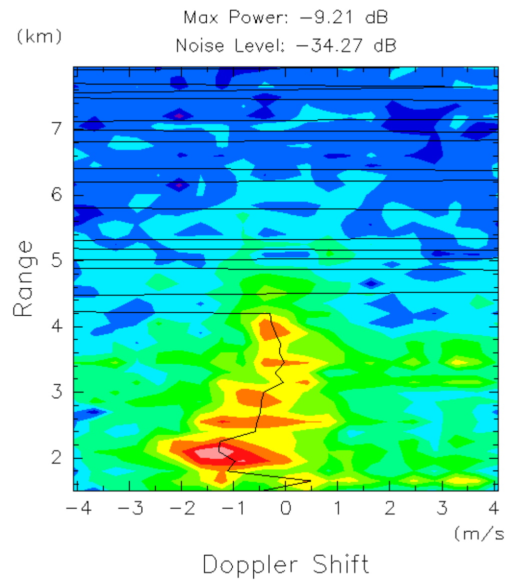
- 19 main antennas (1 group)
- 3 FAI antennas
- Receiver of 4 channels

Currently observations of 1μsec × 8 bit Spano codes in 5 beam directions were successful.

“Sumire” is Japanese name for small violets

8bit Spano code observation





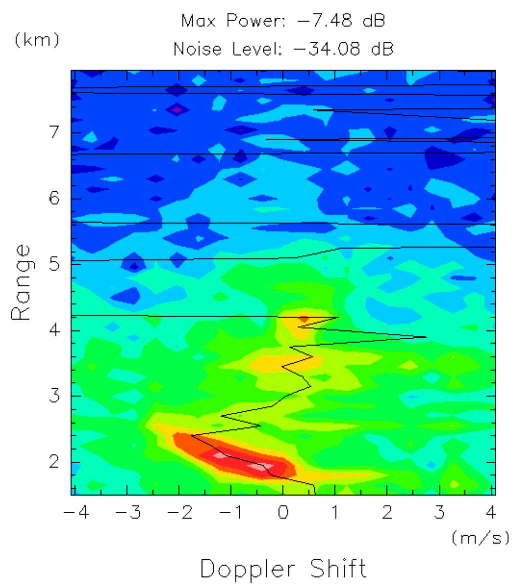
Vertical

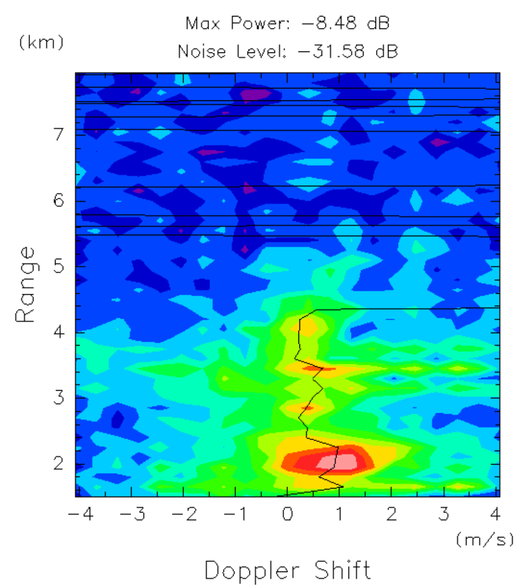
N

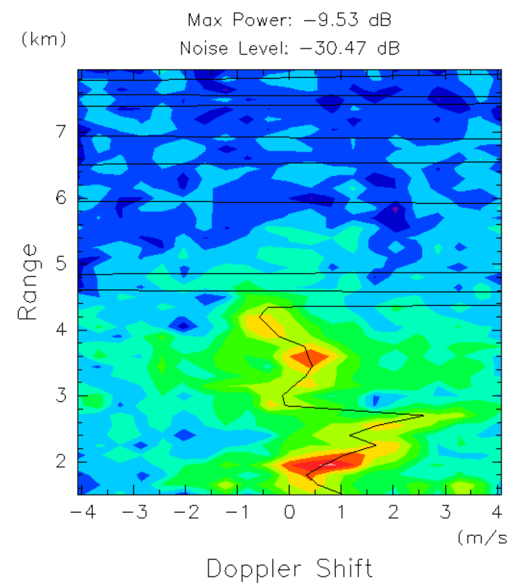
W E

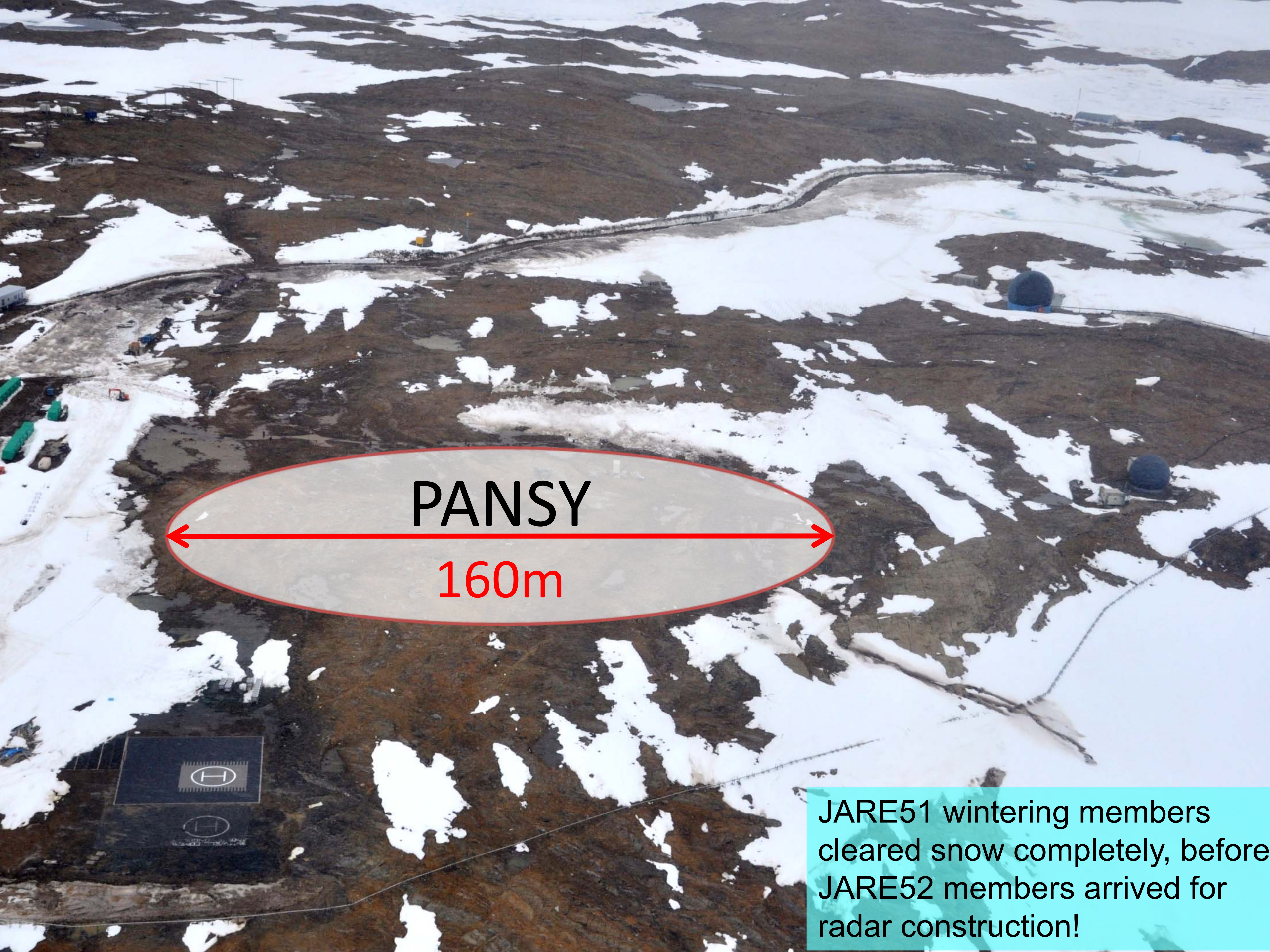
S

(Azimuth =10°)



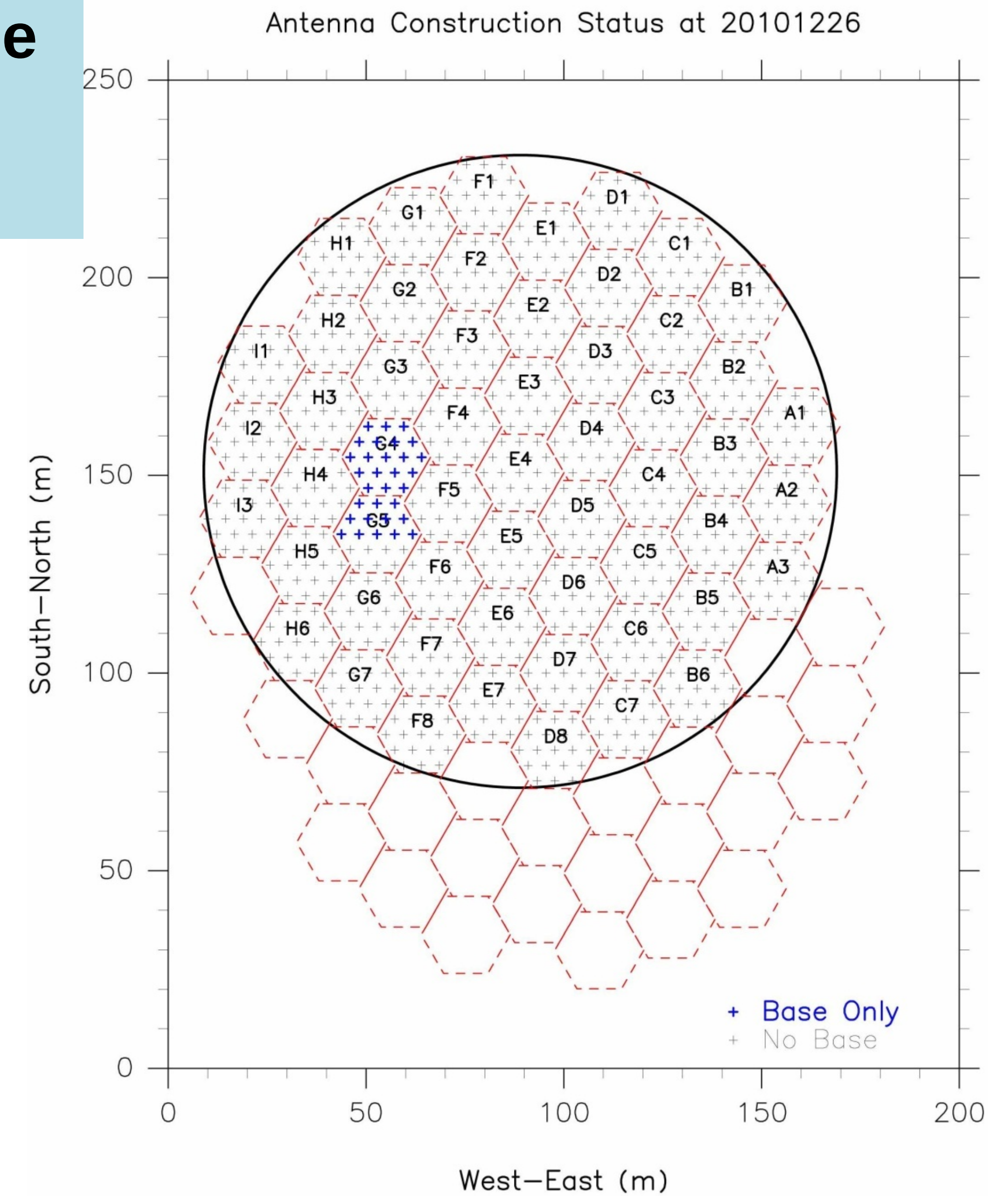





PANSY
160m
JARE51 wintering members cleared snow completely, before JARE52 members arrived for radar construction!

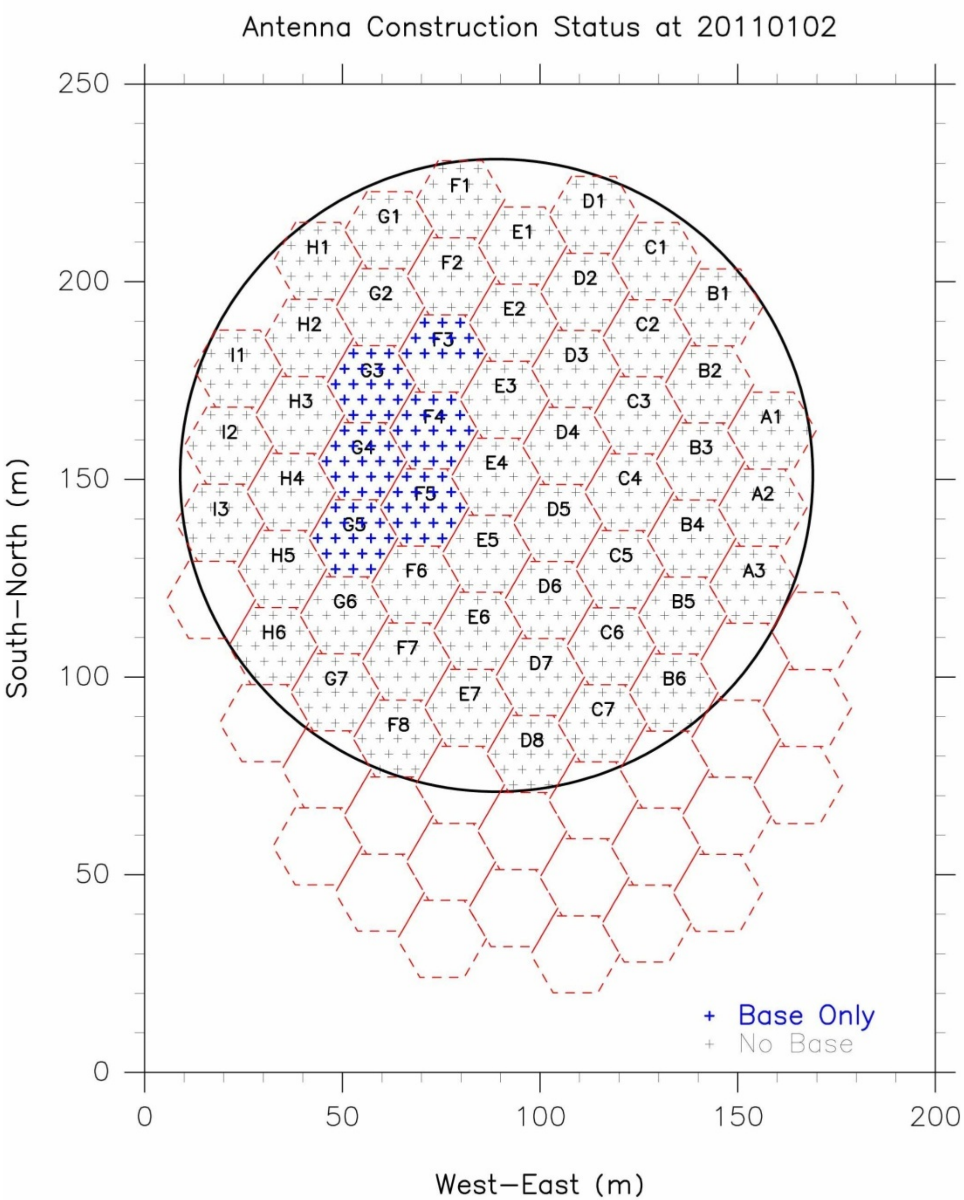
December 26, 2010

The first state of the radar construction that should be made this austral summer is to make antenna bases.



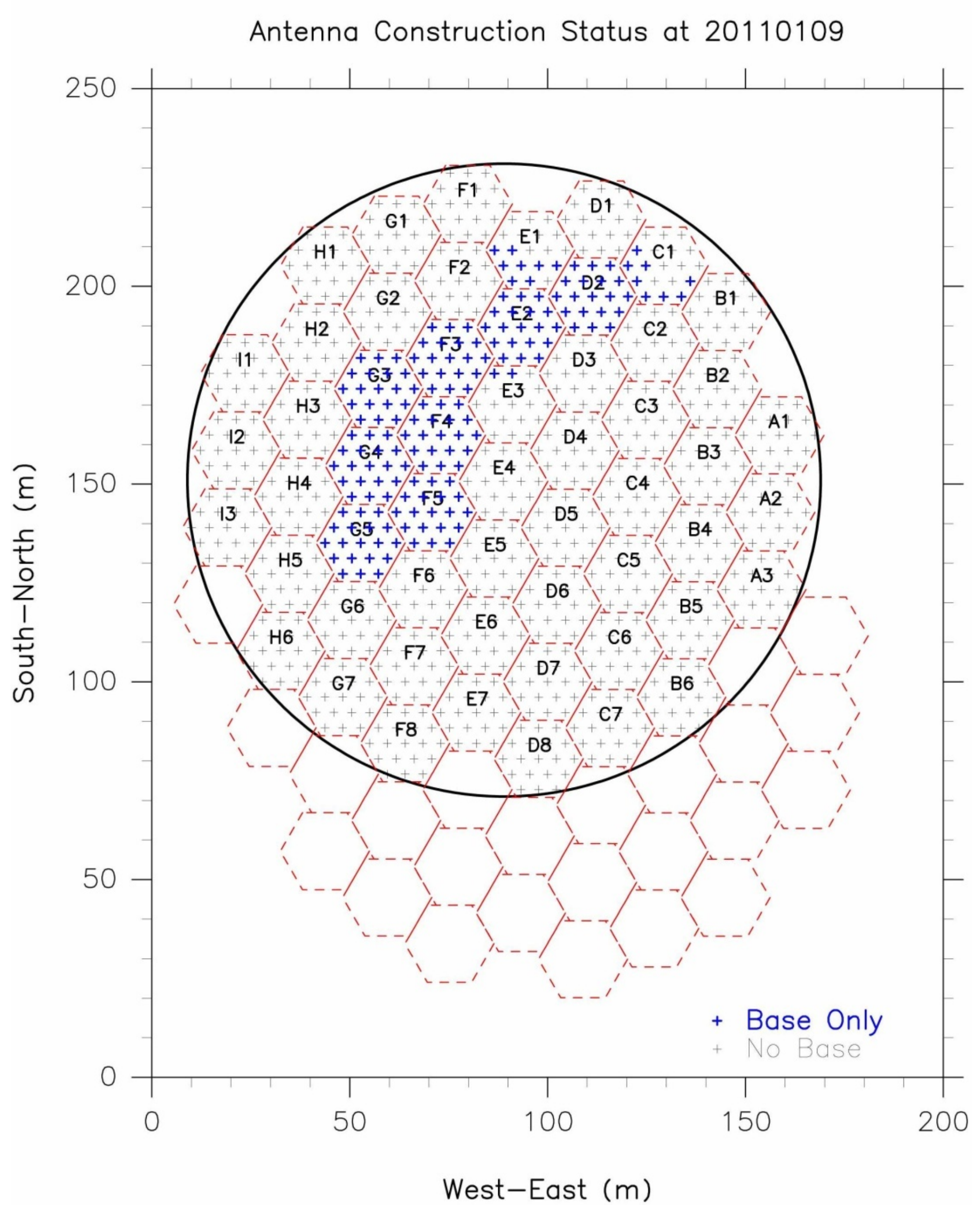
Start constructing 1098 bases

January 2, 2011



New year day

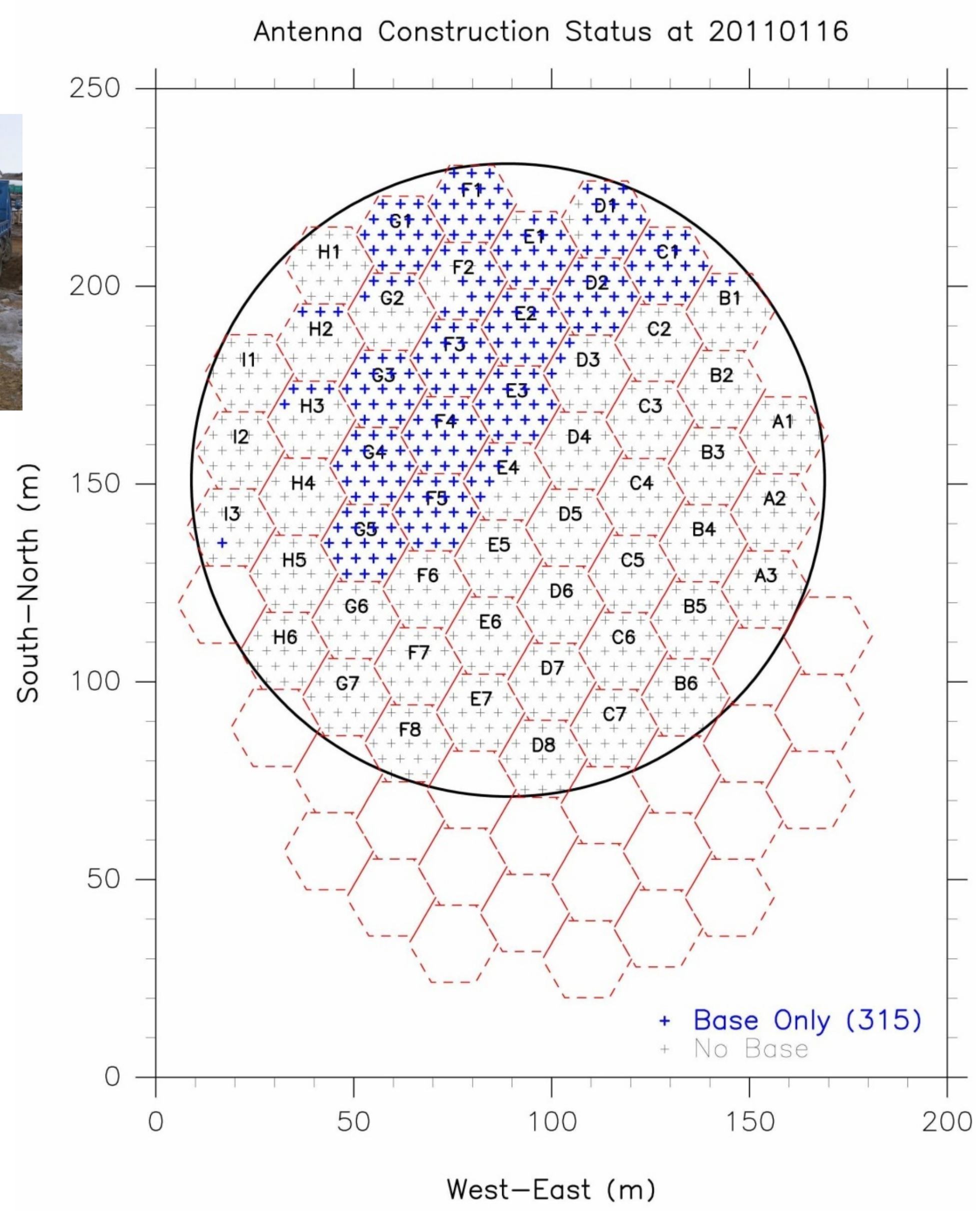
January 9, 2011



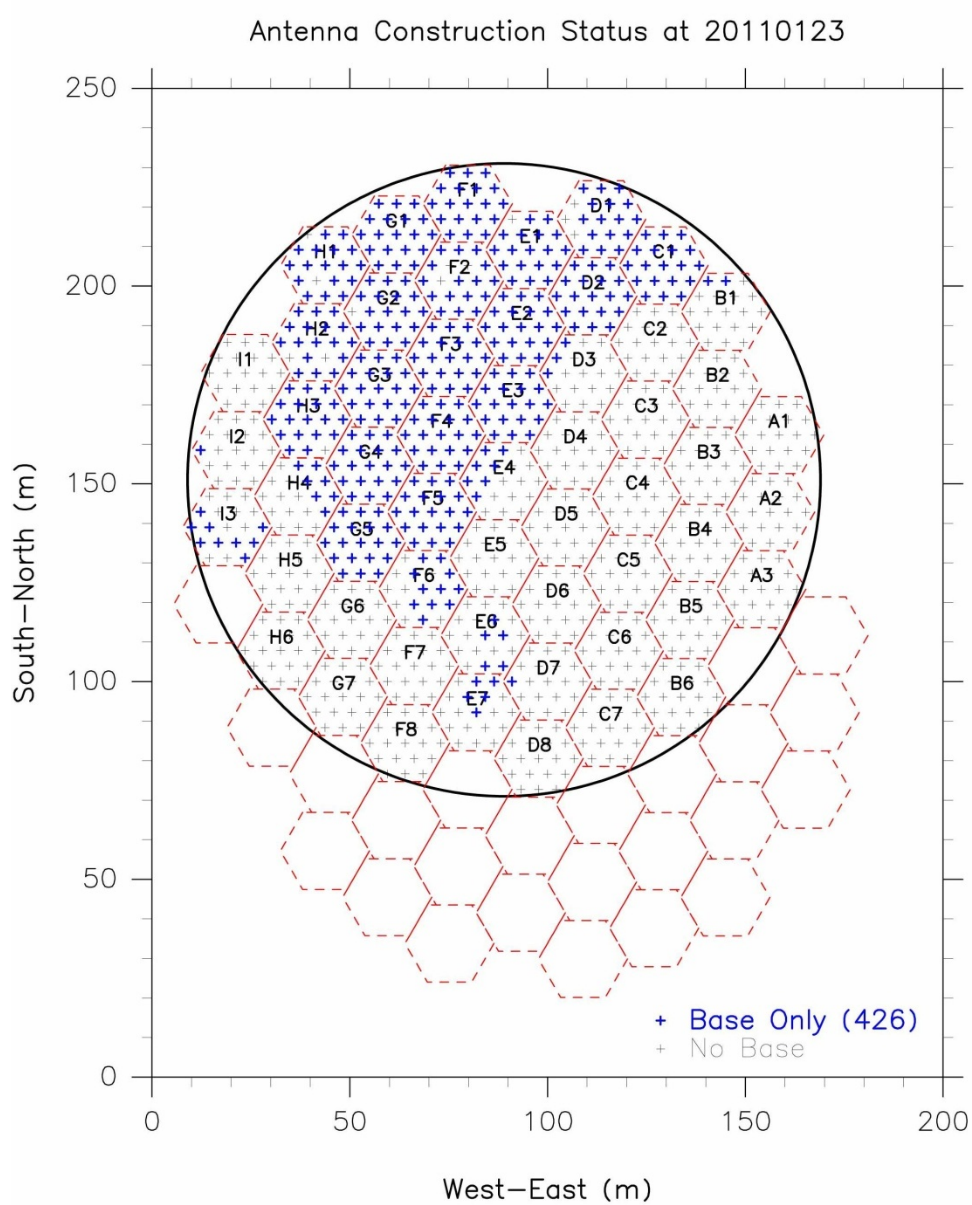
100th antenna base

January 16, 2011

The radar hut construction started.



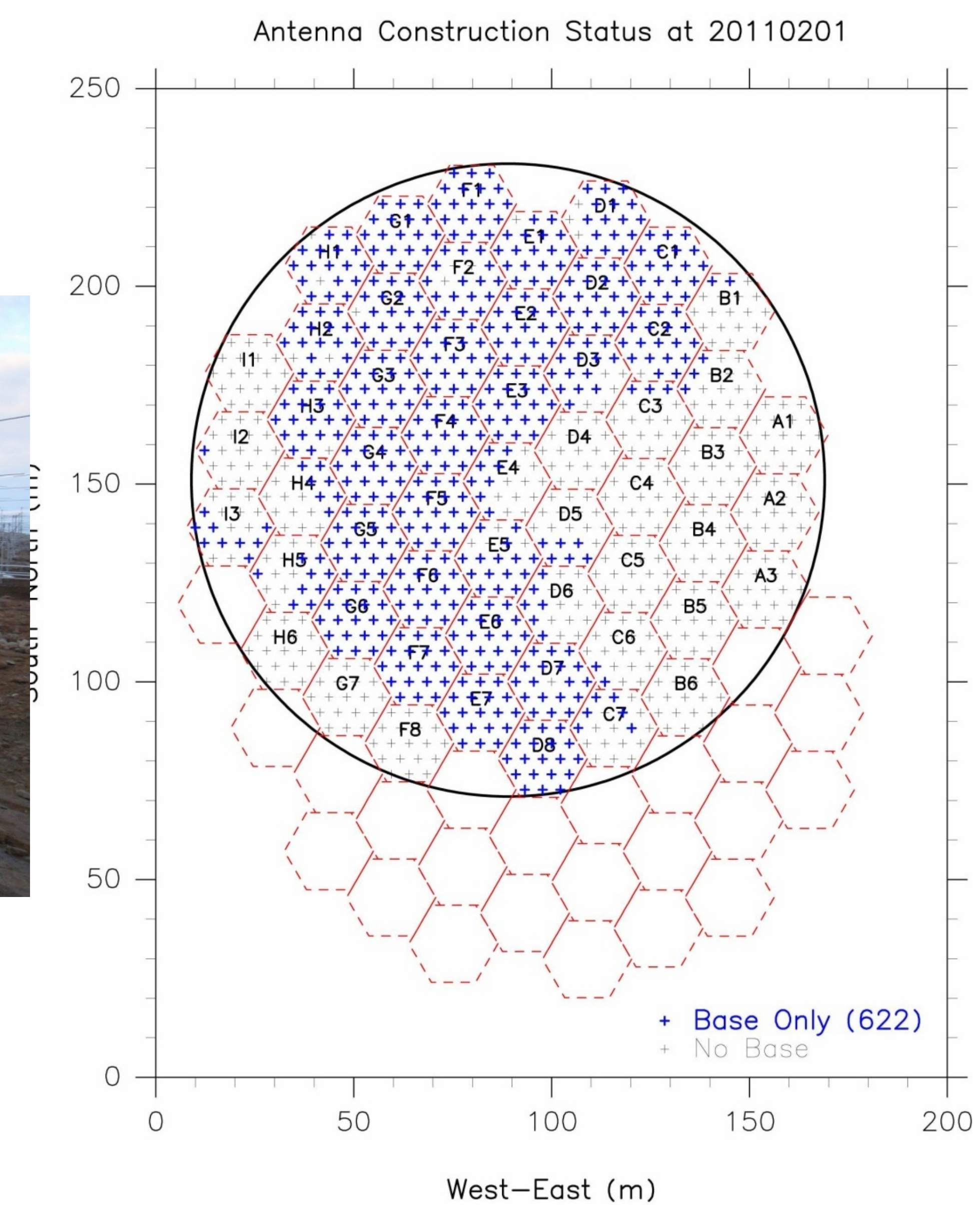
January 23, 2011



500th antenna base

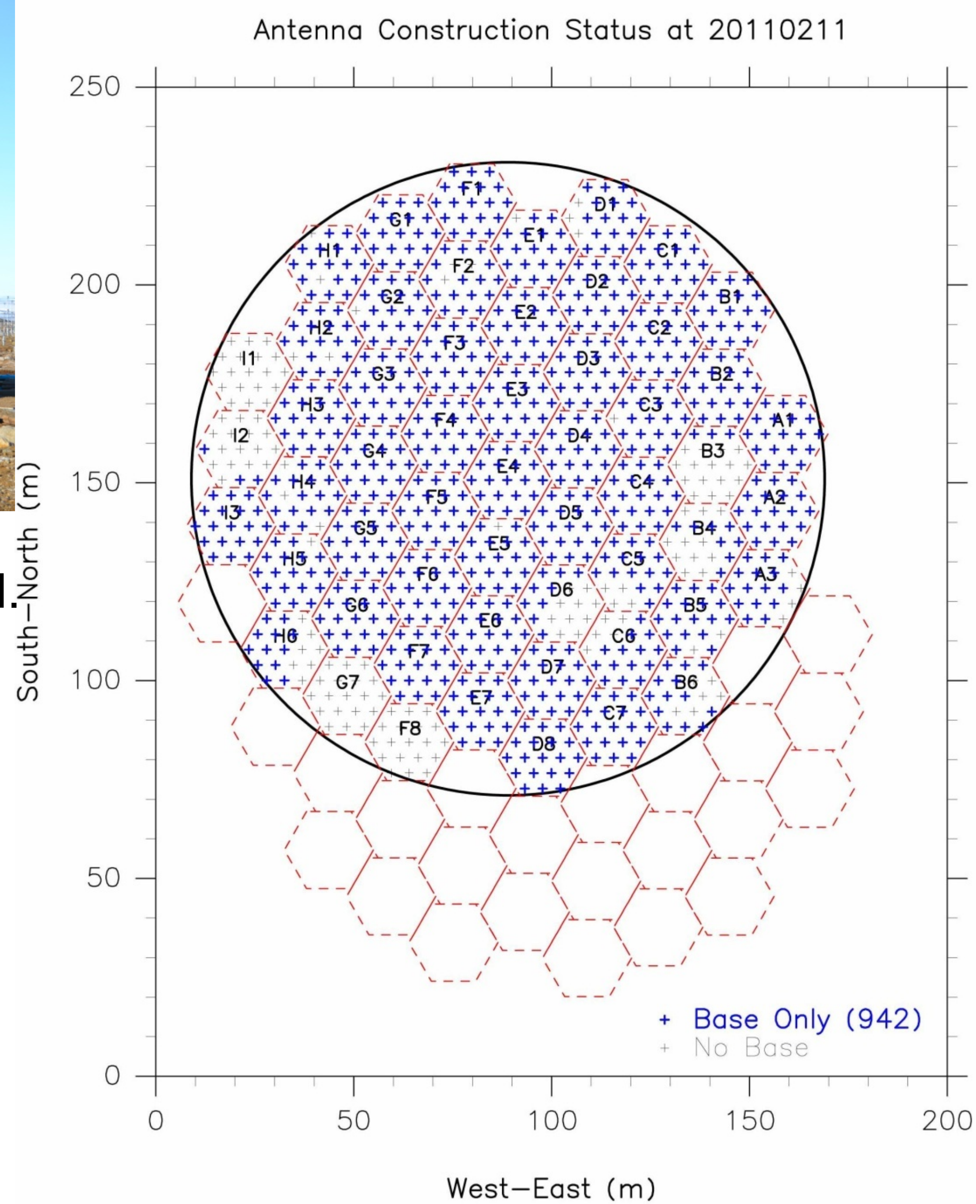
February 1, 2011

Antennas and modules

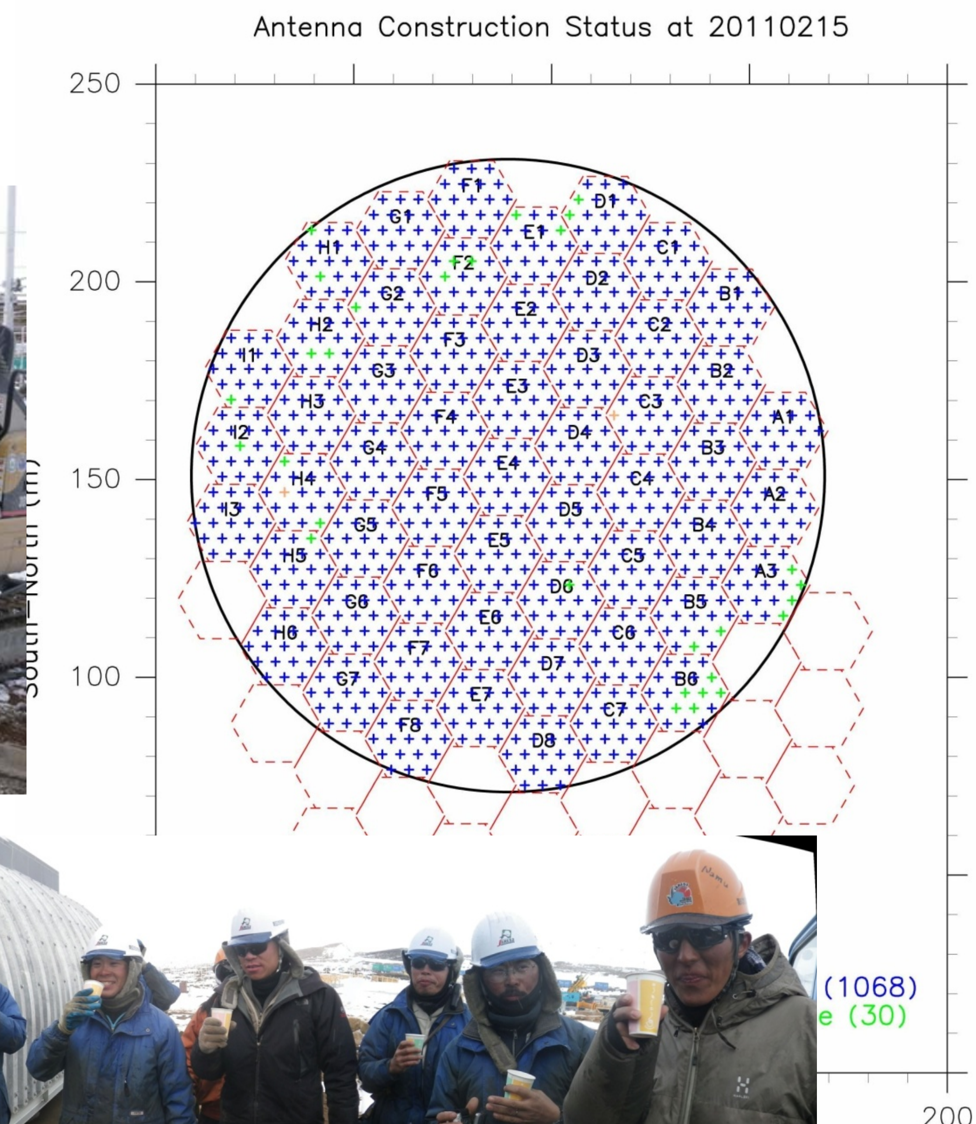


February 11, 2011

The radar hut construction is completed.

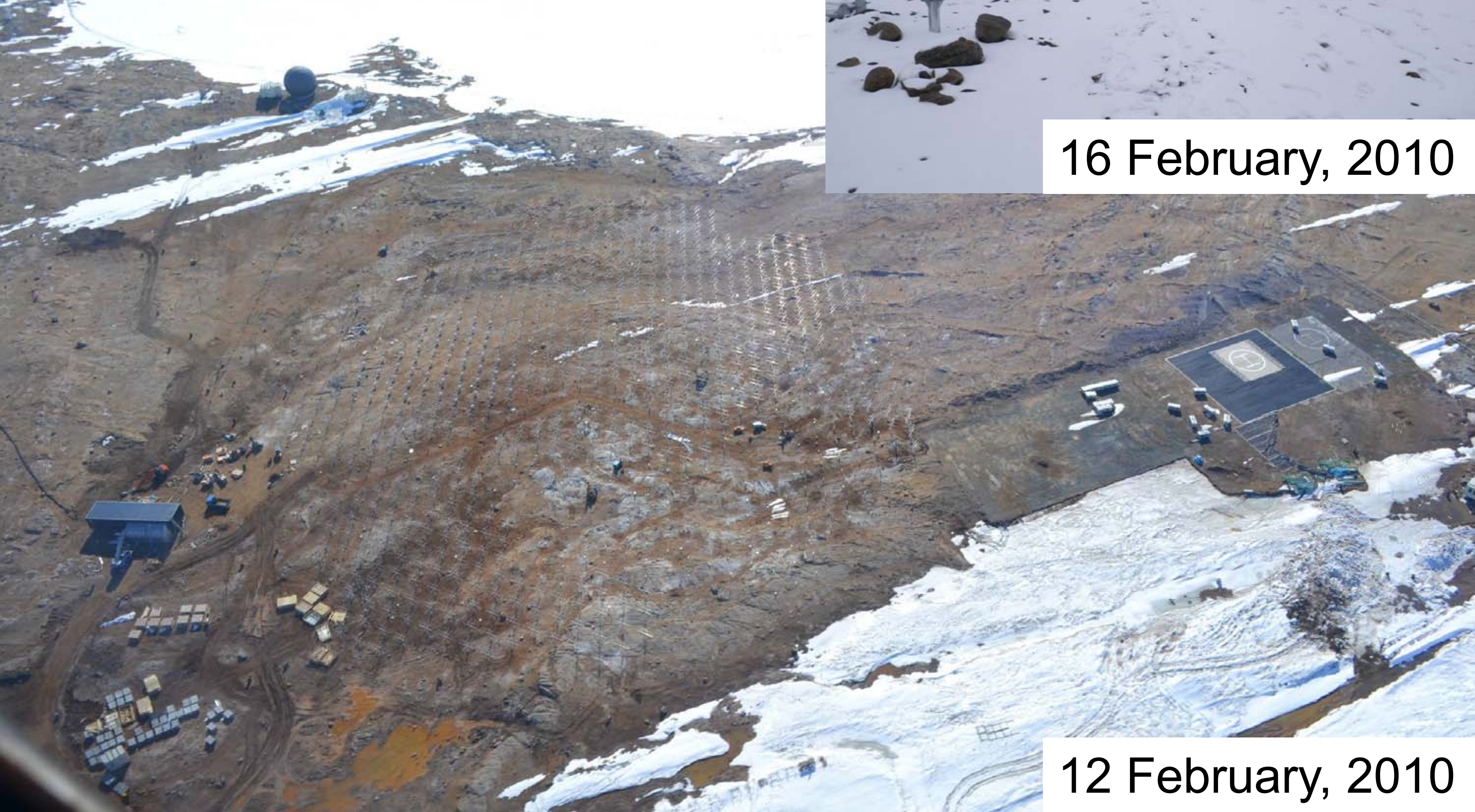


The last (1098th) base was completed on Feb 15, 2010.

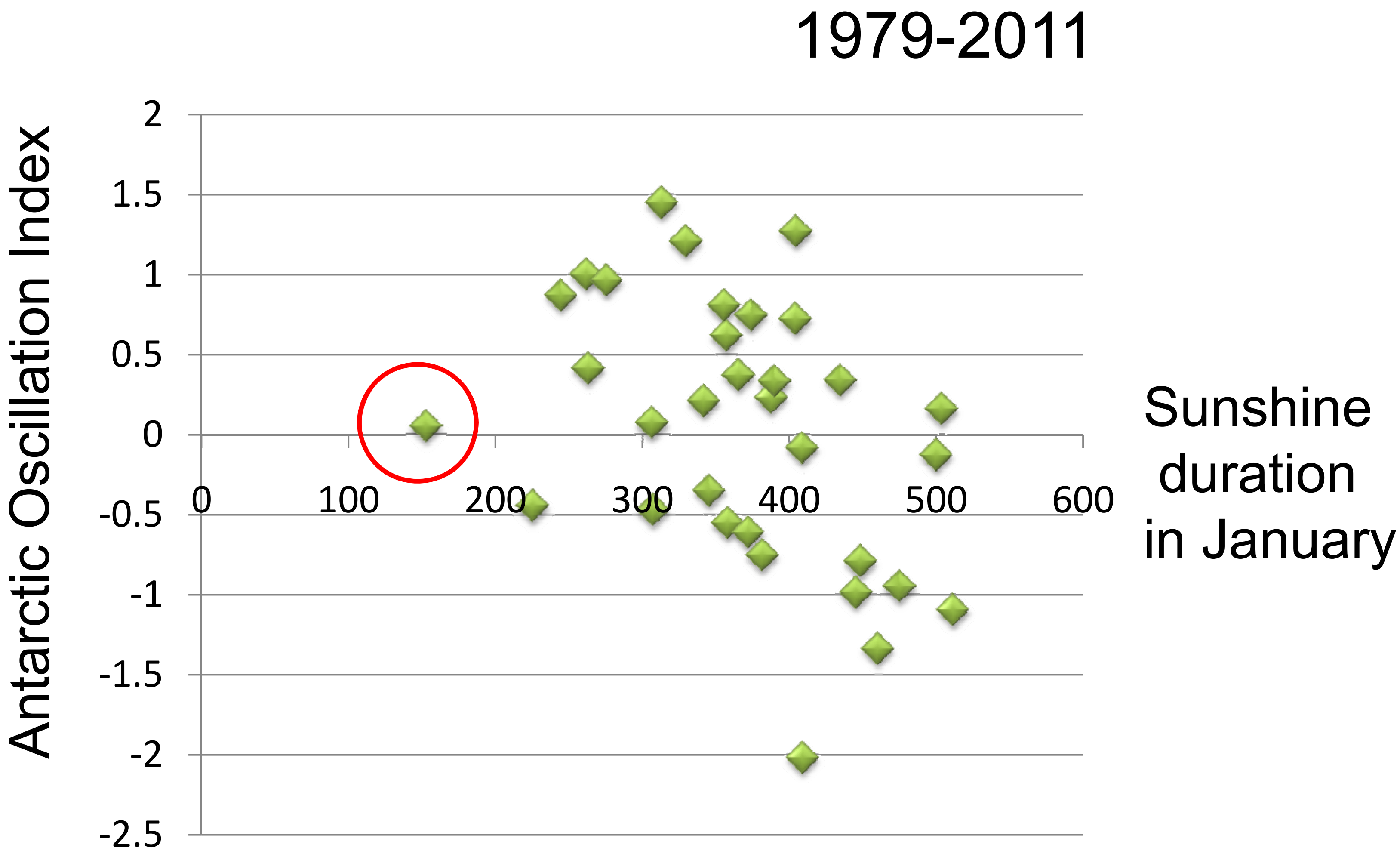


Kanpai! Cheers! Prosit! Toast! Tintin! ….

16 February, 2010

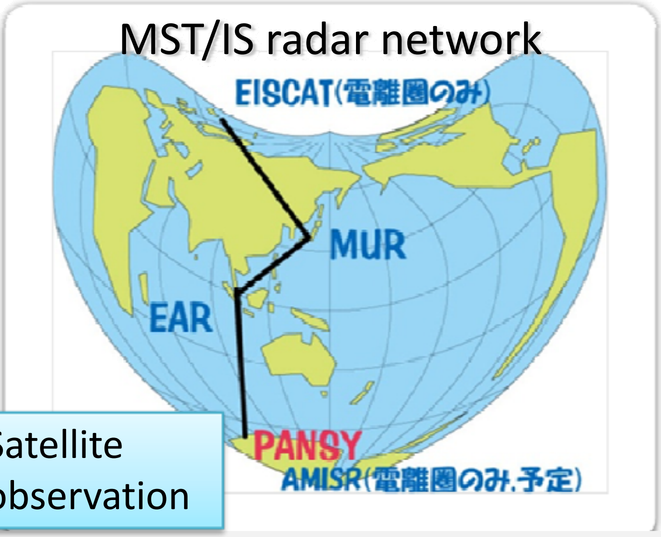


12 February, 2010



The worst meteorological condition!

Comprehensive study of the polar atmosphere using the PANSY radar, in combination with various observations and high-resolution numerical models



Satellite observation

Global connection of the atmosphere
Difference between the Arctic and Antarctic

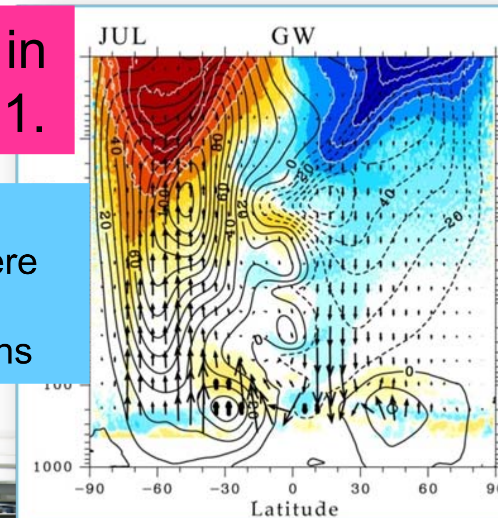
Fine resolution observations of three dimensional winds in the troposphere/stratosphere/mesosphere & plasma parameters in the ionosphere

A quantitative study on the momentum balance including gravity waves

Will start in early 2011.

Real atmosphere observations

Virtual atmosphere model simulations



Coordinated observations on the vertical coupling of the Antarctic atmosphere