EVOLUTION OF PERMANENT SURFACE WATER ICE AT HIGH NORTH LATITUDES

• OMEGA provides a unique capability to study surface ices:
  - strong signatures of H$_2$O and CO$_2$ between 1 and 5 µm (see next two talks)
  - S/N > 300 from 1.1 to 2.6 µm (four major and minor water ice bands)
  - spatial resolution (IFOV) of 1.2 mrad

• Orbital evolution and season provided a major window of opportunity from the solar conjunction (09/2004, close to the northern summer solstice) to end of January 2005 (light levels drop as the fall equinox gets closer)

• During this period, the pericenter moved North by ~ 70°
  The altitude over the pole decreased from 4000 km (5 km pixel size) to 600 km (< 1 km pixel size)

• OMEGA obtained nearly global maps of high latitude northern regions at resolutions of 3 to 5 km in the first two months of summer, then higher resolution observations.
PURE H₂O ICE REFLECTANCE SPECTRA

Strong dependence on grain size

Scattering at interfaces is unchanged, but the length of the path within ice increases with size → saturated bands

Model: Schmitt and Douté
Ls 93° to 98°

most of the central regions are dominated by small grains (< 100 µm) surviving seasonal frost?

outer regions have larger grain sizes (~ 1 mm) low albedo contrast in the continuum
Ls 101° to 104°  
(two weeks later)

small grained  
water ice  
(< 100 µm)  
loses ground

outer regions  
get brighter

The distribution  
of surface ice  
(red to yellow) is  
very similar  
to albedo  
contrasts from  
Viking (1976)
Ls 107.4° to 110° (one month later)

no major evolution of the areal distribution of surface ice

only a few patches of small grained ice survive (region A) « snow drifts »?

Regions of interest have been defined so as to follow spectral evolution:

A: small-grained ice
B: central cap
C: Korolev
aerosols
most effective for large incidence

DUST CONTRIBUTIONS
much more model dependent than ice grain size

areal mixture
surface grains
dust patches

intimate mixture assumption:
largest ice contamination levels

intra-mixture
**Region A (343° E, 80.2° N):**
little evolution over 70 days

radiative transfer model results:
80% small ice grains (< 50 µm)
17.5% ice grains (50 to 200 µm)
2.5% dark dust (5 µm)
(upper limit: intimate mixture)

Long term survival of small-grained ice: thick « snow drift »?

**Region B: central cap (42.5° E, 85° N)**

**Ls 93.3°:** similar to region A

**Ls 127.6°:** large-grained ice
5% dark dust (5 µm)
25% small ice grains (< 50 µm)
70% large ice grains (700 to 800 µm)

Sublimation of surface frost, exposing old, large-grained ice
dust contamination is at most minor
dominated by large grains since Ls 93.6° (70% ice grains \(\sim 800 \mu m\))

upper limit of dust content (intimate mixture assumption) decreases from 10% to 5% over one month

**typical evolution for outlying regions:** initial low albedo contrast in the continuum (brightest dusty regions: also 45% albedo)

albedo contrasts in the visible are not reliable for mapping surface ice

- Increase of albedo, contrast of ice bands between Ls 93.6° and Ls 107° → **clean-up process linked to sublimation**
  (alternate: global aerosol cover from 70° N to 80° N, getting thinner with time)

- reflectance at 2 \(\mu m\) is only 2% at the end. Most likely **very clean old ice**, (taking into account possible areal or intra-mixture dust contamination)
ONSET OF WATER ICE CLOUD ACTIVITY

Ls 107.4° to 110°  
Ls 112° to 115°

Transient weak water ice signature: ice-rich clouds

(presentation by B. Gondet on Wednesday)
Ls 115° to 145°: ice clouds + changes in surface ice properties

no evidence for frost formation on circumpolar dust deposits
CONCLUSIONS

• OMEGA directly maps surface water ice
  Seasonal or year to year changes reported on the basis of albedo in the visible have to be considered with caution.

• major changes in albedo observed after the summer solstice (Ls 93° to 145°) result from two competing processes:
  - in central regions, the sublimation of a bright, small-grained surface layer (< 100 µm) exposes larger-grained « old ice » (~ 1 mm) with a lower albedo
  - in outlying regions, a clean-up process lowers the dust contribution from aeral, intimate or intra mixing (possibly also due to a change in aerosol optical thickness).

• the extent of surface ice is stable over 4 months,
even if minor changes are observed at the fringes, in particular after Ls 115°, which corresponds to the onset of ice cloud activity

• up to Ls 145°, there is no evidence for frost formation on dusty areas
  It may occur preferentially on the colder ice-rich areas
DUST CONTRIBUTION

much more model dependent than grain size

several contributions:

• aerosols
  lower light level on the surface: lower apparent albedo
  backscattering contribution: lower spectral contrast of ice bands

• areal mixture: sub-pixel dust patches or isolated dust grains on the surface
  linear combination of ice spectrum and dust spectrum
  lower albedo, lower spectral contrast of ice bands

• intimate mixture: dust grains mixed with pure ice grains
  different scattering properties at grain interfaces
  lower albedo, lower spectral contrast of ice bands

• intra-mixture: small dust grains within large ice grains
  photons can be absorbed or scattered before reaching ice grains interfaces. Very effective process for lowering the albedo
  extreme example: dust grains within a thick slab of water ice
  same scattering properties (and albedo) as pure dust in the continuum