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Description of Polar Orbiting Satellite Data Available During the Fall 1991 and Spring 1992 Ice Station LEADEX Deployments

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CIRA Cooperative Institute for Research in the Atmosphere

Colorado State University

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TECHNICAL REPORT
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Satellite data from polar orbiting satellites are indispensable for studying the development of subsynoptic and mesoscale meteorological phenomaena over and near the arctic basin where conventional meteorological data are few or not existent at all. Without satellite data (images) the interpretation of local "spot-measurements", will be hazardous and often impossible.
Because of the large "overlapping" between succesive orbits at high latitudes satellite data with a high temporal resolution in principle should be available for a detailed meteorological analysis. In practice, however, the amount of data (images) is usually severely limited by several factors including "practical problems" related for example to the retreaval and archiving of the data, as well as "basic physical problems" as for example that images in the visible channels are not very useful during the cold seasons.

For meteorological purposes data from the following polar orbiting satellites may be available in the period considered: NOAA, DMSP, GEOSAT and ERS-1. In case data from all of the satellites should be available then in principle a very detailed analysis should be possible including information about the surface wind field, thermodynamic structure og the atmosphere etc etc ,assuming that the development considered takes place over the sea. However,it is only in very special circumstances if ever, that all possible data will be available. In the following is briefly summarized the possibilities and advantages/disadvantages of the different satellite observing systems of interest for meteorological studies of subsynoptic/mesosacle developments over or near the arctic basin.

NOAA
Data from the NOAA satellites include images in the visible and infrared part of the spectrum, as well as images from the near infrared channel 3. In addition TOVS data are available from these satellites.
The high resolution (AVHRR) data in the visible channel(s) are very usefull when available for studies of developments in the region. Unfortunately these data are not available during the cold seasons when little or no daylight is present.
Images from the infrared channel(s) are likewise very usefull and for long periods the only ones available.
Channel 3 data are very seldom used. However, it has been pointed out, that these images may contain more significant meteorological

information than the visible or infrared channels. The use of Channel 3 data for arctic basin studies should certainly be encouraged.
TOVS, the Tiros Operational Vertical Sounder also flies aboard the NOAA satellites. Although the soundings made from TOVS data in a statistical sense corresponds fairly good to radiosonde observations it still remains to be demonstrated that these soundings are usefull for subsynoptic/mesoscale studies, especially in the arctics over ice/snow covered regions.

A very important "practical" problem pertinent to all the data mentioned about are where to aquire the data. To the author's knowledge the full resolution NOAA data are not systematically archived anywhere in the world. NOAA data (GAC) with a reduced horizontal resolution around 4 km, may be available at NOAA/NESDIS/NCDC Satellite Data Services Division, Washington, D.C. Because of the limited archiving it is extremely important to ensure the reception and archiving of the data in connecton with any experiment where satellite data are of importance. Because of the "overlapping" a good temporal resolution is possible provided all possible images are received and archived. Unfortunately for most case studies usually only one or two images are available.

"Old" TIROS/NOAA images may be locally available, and for the Atlantic /European sector data may be obtained from the Dundee archive in Scotland. Around five to six passes ,central or nearly so to the British Isles, are normally archived for each day and shown in the very usefull "Browse Files". All these data are also available in digital form. Unfortunately the data cover only a relatively small part of the region of interest for arctic related studies.

DMSP
The DMSP (Defense Meteorological Satellite Program) satellites observe in the visible, the infrared as well as in the microwave part of the spectrum.
The high resolution visible and infrared images are, like the corresponding NOAA images, highly relevant for arctic studies. Unfortunately the DMSP full resolution images are not systematically archived. Some high resolution images may be obtained from the National Snow and Ice Data Center in Boulder and a resonable complete archive seems to exist for the 4 kilometers mosaics. These mosaics, however, are of limited use for subsynoptic studies of arctic phenomena.
A special light sensitive sensor aboard the DMSP satellites allows the use of a visible channel even during wintertime. These "nighttime visual data" are made possible by illumination by moonlight. In order for the instrument to work the phase of the moon must be quarter or more.
The microwave data obtained from the Special Sensor Microwave/Imager (SSM/I) are unique for the DMSP satellites. By means of suitable algorithms these data provide information on integrated water vapor, integrated liquid water (cloud droplets and

rain), on the precence of large ice crystals (deep convection), and surface wind speed, but generally only over the ocean. In case the phenomena of interest occurs over an ice free ocean region (as a polar low development probably will) SSM/I data may provide significant information additional to that provided by the "conventional" visible and infrared images. Because of the special conditions in the arctic (a low total water vapor content close to detection limit of the instrument and the presence of numerous ice particles in the clouds) it still remains to be seen how usefull the SSM/I data wil be in these regions.

GEOSAT
The nadir- viewing radar altimeter system onboard GEOSAT observes the wind velocity over the sea at a point directly beneath the satellite. The algorithm used is applied to the ocean backscatter coefficient and as such only works over the sea.

ERS-1
The ERS-1 was succesfully launched at July 1991 and data will be available from December 1991. In special cases SAR data may be used for meteorological studies, but apart from that the surface winds data from the scatterometer are most relevant for meteorological purposes. Again the instrument only works over open water which severely limits its possible applications for studies over the arctic basin. For studies of phenomena like polar lows which often develop over the ocean, close to but away from the ice or snow covered regions, the ERS-1 scatterometer surface wind data will be very useful.

Concerning the availability of satellite data for the fall 1991 and spring 1992 (low light period) LEADEX experiment it must be concluded, that the most important data probably will be the infrared images from the NOAA and DMSP satellites. Nighttime visual data from the DMSP satellite may be used in the whole period as well, and depending on the time of the year, also visible data from the NOAA satellites.
TOVS data may be usefull for construction of the large scale synoptic bacground field in which the subsynoptic disturbances develop. The French 3I algortihms for the retreaval seems the most promising system, but it still reamins to be seen how well it works over ice covered regions. Even if the TOVS is able to delineate synoptic features in for example the 700 to 500 hPa thickness field it is doubtfull whether these measurements will be able to provide reliable information about the conditions in the lower layers close to the surface including the low level inversions which are very important especially in arctic regions.

Description of Mesoscale Phenomena in the Arctic Basin

Only little is known about mesoscale phenomena over the arctic basin. Among the most interesting phenomena in the present context are 1.arctic fronts and 2.mesoscale cyclonic vortices.
According to Sechrist et al.(1989,p.4-34), "Arctic fronts are so

named to distinguish frontal activity and associated jets over the ice cap from coexisting polar frontal activity of midlatitudes. Arctic fronts are generally less intense than polar fronts,however, marked changes in cloudiness, in wind direction and speed, and in temperature often accompany their passage". The cloud systems to these arctic fronts can often be observed on infrared satellites, but their effect on the surface may often be masked by the large, low-level stability which allows local effects to predominate over clasical frontal behavior (Sechrist et al.p.4-28). In addition to these fronts resembling their southerly counterpart, the Polar Front, other types of low level arctic fronts are sometimes observed. These "boundary layer fronts" which may be very sharp are typically observed over the sea, close to the ice edge, but occasionally also over the ice far away from the ice edge.

A survey of satellite images has shown that mesoscale vortices quite often can be observed in the interior part of the arctic basin, especially in the summertime. These "vortices", however, seem to be associated only with low level stable clouds (st/sc) and the associated circulation is probably weak.
"Real" polar lows associated with deep convection are not very likely in the LEADEX region in the low light period when the sea is almost wholy covered by ice. A recent investigation (Parker, 1989) based on ten years of data from 1976 to 1985 showed only one case of a polar low development which affected the southern Beaufort Sea. This low formed in the Chukchi Sea on October 13,1985 and subsequently moved East. After making landfall close to Point Barrow, the low moved back over open water , passing about 60 nm north of Prudhoe Bay before moving over the ice pack and weakening. The maximum reported gust during the event was 139 km/hour from Prudhoe Bay.

RECOMMENDATIONS

1. All visible and infrared images available from the NOAA and DMSP satellites should be received and archived as part of the experiment. If only hard copies can be archived these copies should show "close ups" as well as the whole region.
Provided all passages are saved in digital form it might be possible in some cases to derive the horizontal wind field at selected levels by a cloud tracking method. The possibilites for that should be investigated.

2. An attempt should be made to utilize the Channel 3 NOAA images.

3. TOVS data should be used with caution (especially in connection with studies of mesoscale phenomena), and it is questionable whether it is worthwhile to put in too much effort into work with these data before their usefulness has been further documented (such a documentation may be under way though).

4. Since microwave data generally only are usefull over the ocean

DMSP/SSM/I microwave data will probably be of only limited use except from providing additional data for adjacent ocean areas (the Gulf of Alaska). For the same reason data from GEOSAT and ERS-1 (scatterometer-data) will be of limited use. SAR data , if/when available, may provide some interesting meteorological information.

Reference

Sechrist F.S., Fett R.W., and Perryman D.C. 1989: Forecasters Handbook for the Arctic, Naval Environmental Prediction Research Facility, Monterey, CA, Technical Report TR 89-12