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Wind and Current Sensors

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WIND & CURRENT SENSORS

1. INTRODUCTION

DP positioning in deep water is influenced by winds and waves acting on the above water portions of the vessel and waves and currents acting on the below water part of the hull as well as the drilling riser in the case of exploration drilling. Winds are routinely measured while drilling from the top of the drilling derrick for helicopter operations, and that data with normally visual observations of wave conditions are transmitted and available over the GTS (Global Telecommunications Service) and even through Internet sites (see for example oceanwx@oceanweather.com page on marine observations) in near real-time. Measurement of currents is normally conducted during drilling operations when there is concern that currents may influence station keeping and drilling riser management. Thus in areas subject to weak currents perhaps only a conventional current meter lowered over the side of the vessel might be used for occasional measurement of currents at one or more levels. In strong current areas, on the other hand, profiling instruments are routinely used to measure currents throughout the water column. Currents below the vessel hull have an indirect effect on the vessel positioning since they affect drilling riser management (i.e. maintaining low riser angles).

An ultimate goal in the physical environment is prediction or forecasting. While wind forecasting is far from perfect, current forecasting is in only in its embryonic development. The reason is primarily due to the lack of observations of ocean currents compared to wind observations, which is a result of the greater cost of current observations.

The ability of a DP vessel to weathervane into the direction of the environmental forcing, extends the operational weather window of DP operations and reduces the need to use thrusters to maintain position. The weathervane approach can be seriously hampered when the environmental forces are not aligned and in particular when they are offset by 90 degrees. While winds and waves are often aligned, currents on the continental slope and deep ocean are not forced by winds and therefore are only aligned by chance. Thus the vessel operator must decide whether it is better to face the vessel into the wind and take currents broadside of vice versa.

Since the technology of wind measurements and forecasting is much more advanced than currents the rest of this paper will deal with ocean current technology.

2. CURRENT MEASUREMENT TECHNIQUES

2.1 On-Board Measurements

2.1.2 Conventional Current Meters

Conventional current meters, as used here, measure currents at the position of the meter by counts of rotation of a rotor, electromagnetic techniques or acoustic techniques. In the simplest use, an internally recording instrument may be lowered over the side of the vessel using a winch to a prescribed depth with a suitable weight to keep it vertical. Besides current speed and direction, sensors may be included to measure temperature, salinity and depth. After a suitable measurement period the meter may be lowered to obtain readings at additional depths to observe the variation of current with depth. Data from the internally recording instrument are downloaded when brought back to the deck for processing and interpretation.

Conventional current meters may also be used to obtain data in real-time through connection of the meter through an electromechanical cable to an onboard personal computer. In this configuration the data may be displayed, updated and stored with the PC. The downside is the need for slip rings on the winch for power and communications.

2.1.2 Current Profiling

The capability to measure real-time current profiles to support deep water drilling activities began over ten years ago. The measurement system comprises a low frequency RD Instruments Acoustic Doppler Current Profiler (ADCP) suspended just below the vessel hull. This is connected by cable to PC situated in the vessel control room. Software are available to provide two-way communications with the instrument, a series of screen displays of current data and also data storage to disk. Many successful deployments of this type of system have been undertaken world-wide.

The ADCP projects four acoustic beams downwards through the water column. The beams are inclined at 20 or 30 degrees to the vertical, and at 90 degree spacing in plan view. The transmitted acoustic signals are reflected from scattering particles in the water column (plankton, suspended sediments etc.). Thus, an echo return of the transmit signal is received back at the instrument. By time-gating the return signal, with reference to the speed of sound propagation in water, it is possible to ascribe different parts of the echo return to different layers of the water column (cells). The difference in frequency (Doppler shift) between the transmitted signal and the echo return allows the velocity of the scattering particles along the acoustic beam axis to be calculated. The assumption is made that, on average, the scattering particles move at the same velocity as the water. With knowledge of the acoustic beam geometry, it is then possible to determine current speed and direction at each representative measurement 'cell' through the water column.

In this way, a profile of current velocity is measured remotely from the ADCP suspended just below the drilling vessel. The measurement range is a function of the transmission frequency of the instrument. A low frequency 75 kHz ADCP can achieve a range of approximately 700 meters in optimal conditions. Range is influenced by a variety of factors such as background acoustic noise, scatterer density and water temperature and salinity.

2.1.3. Recent Developments in Current Profiling

Often there are several simultaneous operations at a drilling location with each requiring knowledge of current conditions. Initially, an ADCP was operational on the rig working at the central drilling location, and measured information was relayed verbally over the radio to other vessels. Now radio telemetry transmission of current data collected at the central location permits 'satellite' vessels to obtain data real-time on a PC.

During the use of DP station-holding for drilling rigs, there is particular interest in current velocities near-surface, in the region which imposes drag on the vessel hull. In conventional deployment mode, the ADCP system does not provide measurement in the top 50 meters of the water column. Therefore, specifically to support DP drilling, a ‘dual’ ADCP deployment arrangement has been developed. A conventional downward-looking ADCP is deployed below the rig pontoons or hull in tandem with a high-frequency upward-looking instrument. The upward-looking ADCP is able to provide current profile in the immediate vicinity of the rig and thus assess the drag forces acting on it.

2.2 Areal Measurements

In assessing current data at a drilling location it is extremely important to also incorporate current and current related data from other locations in the area for interpretation. In the more familiar context of weather this is similar to having wind observations at a location and interpreting the data with the aid of a weather map. This provides information in the meteorological context of approaching high pressure cells, storms, and fronts, which each have an oceanographic equivalent - warm eddy, cold eddy and meandering current. Unfortunately there is not a network of current observing stations, so areal knowledge is quite limited.

The primary source for this assessment are satellite based sea surface temperature and sea level height, which are available nearly real-time. Strong temperature and height gradients indicate strong currents. The limitation of the thermal data is that clouds interfere with the measurement and that the surface thermal expression of ocean currents are obscured during the summer in mid and low latitudes. The altimetry data is presently limited by coverage that is not as frequent or spatially dense to resolve all of the correct scales for currents. Both sources are limited in that they provide only an approximation to current speeds and directions.

In spite of the limitations, the data are used by several commercial companies to provide an assessment of current conditions for the Gulf of Mexico on a subscription basis.

3. APPLICATION OF CURRENT DATA

3.1 Assessment of Site Data

In normal operational mode, software is set up to acquire current velocity profiles once every 10 minutes, for a series of measurement cells of 16 meter length. The principal limitations of the system are first that it does not provide measurement in the top 50 meters of the water column, and secondly that it does not provide measurements in the bottom 15 percent of the water column due to acoustic interference with the sea bed if the water depth is less than about 700m. Additionally, in greater water depths no data are available deeper than 700m.

Software is commercially available to provide the user with a series of readily-interpreted graphical views of the measured data, such as instantaneous profile plots and short and long-term time series at selected depths.

3.2 Forecasting

3.2.1 Ocean Circulation Modeling

Considerable effort has been expended to develop computer models of the ocean circulation in recent decades. These models, similar to weather forecast models, are numerical solutions of the basic physics of fluid flow. Though progress is steady only limited success has been reached in providing operational forecasts. The main difficulties lie in the need for high resolution, which requires considerable computing resources, and the lack of data to initialize the models.

3.2.2 Statistical Extrapolation

A short-term current forecasting system has been developed and tested with some success for certain areas. The model can be used to predict current speed and direction, through depth, over a 24 hour period. The model is a PC-based software package which is used in combination with ADCP measurements.

The model was developed through extensive numerical analysis of previously-measured current profile data. Harmonic analysis was used to determine the predictable tidal component of flow, and then empirical pattern-recognition techniques were developed to estimate the highly-variable non-tidal component of flow. The approach taken was to provide a robust empirical prediction procedure rather than to attempt a full hydrodynamic interpretation of the available data. During the development phase, various prediction algorithms were tested on past data to assess how well they would have performed in real-time. The preferred scheme was then encoded into a real-time software application.

Continued improvements in empirical modeling may provide an effective tool to support operational planning for offshore, world-wide.

3.3 Integration of Current Data with Station Keeping Systems

One of the most critical aspects of a drilling operation is maintaining riser angles within acceptable limits. These angles at the top and bottom of the drill string can be controlled to some extent by design of the configuration of the riser, drilling mud density, tension, and rig position. The main non-controllable factor is ocean currents.

Only limited modeling has been undertaken to develop riser models that incorporate currents. These studies indicate that integrated effects or force parameters associated with the current profile such as the total force and overturning moment are much more important than the detailed current profile. Further work in this area may show that these integrated effects can be more accurately predicted than the profile, thus simplifying the forecast problem.

4. FUTURE REQUIREMENTS

4.1 Full Profile Measurements

Full profile measurements are required by many operators when drilling in deep water. Such measurements are required for estimates of forces on the riser and any other structures extending from the sea surface to the seabed. Such measurements are not possible in water depths greater than 700m with a single instrument. However, new acoustic techniques such as phased array technology are just coming onto the market, which will extend the total range of current profiling.

On a similar note, real-time measurement of near bottom currents is limited to about 1000m water depth. While alternative communications through umbilicals is possible, increased acoustic transmission range would help keep oceanographic measurements independent and not interfering with other requirements.

4.2 Forecasting

The full utilization of current measurements will only be achieved when reasonable forecast methods are developed and validated. Accurate forecasts will have a strong role in planning, which will significantly increase the efficiency of offshore exploration.

This will likely come about through a combination of regional or basin wide circulation models coupled with near real-time satellite and drifter data and with real-time data measured at the site. The approach will likely be empirical at first and rely on the skill of the forecaster but increasingly use more basic physics and be more automatic.

4.3 Integration of Data for Operations

Environmental data needs to be integrated with other types of data collected on DP vessels to be able to model the riser and for station keeping purposes. Such data includes information on the vessel and drilling design (hull design, riser dimensions and configuration, etc.) and real-time data on variables such as vessel position, top and bottom riser angles, drilling mud density, tension being pulled, etc. The digital recording of these data and their integration with metocean data is just beginning.